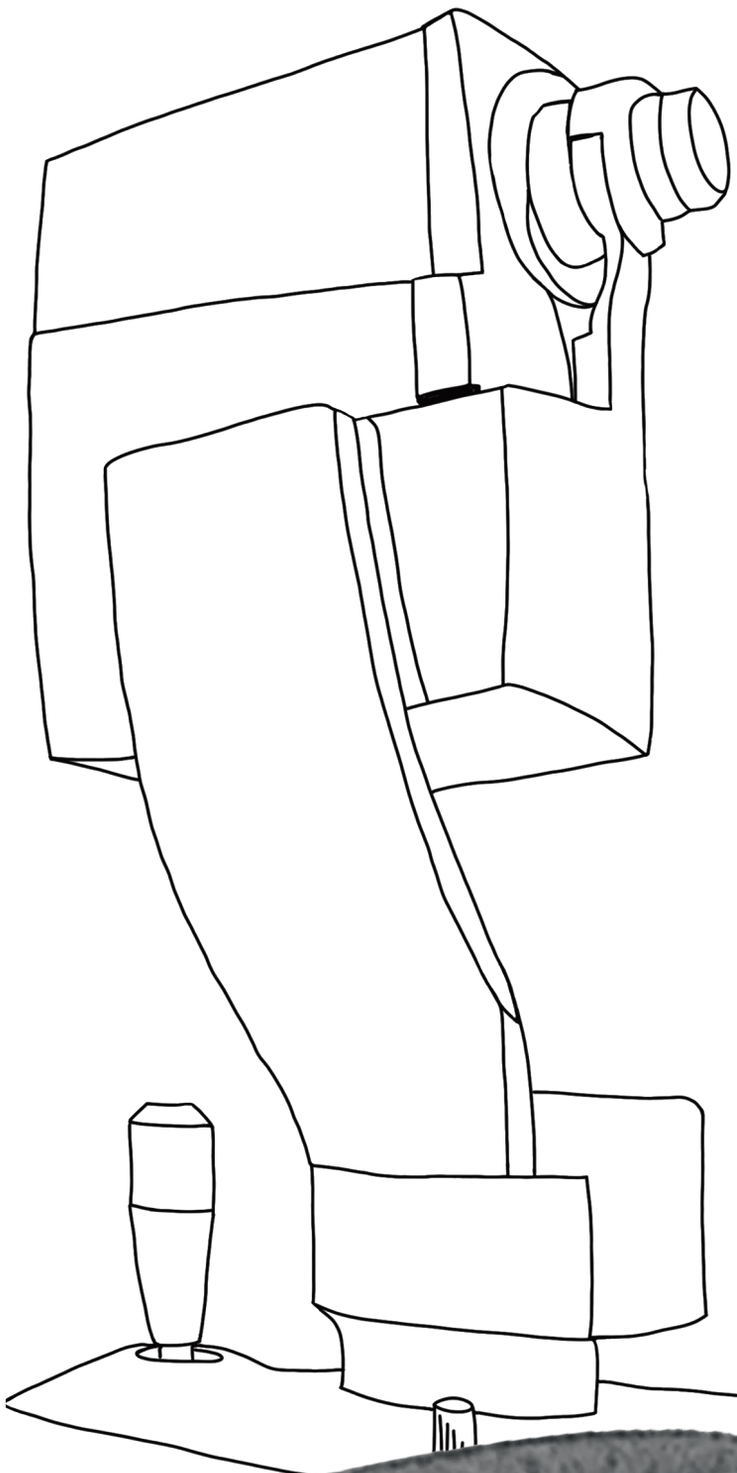
Hanusch retinal

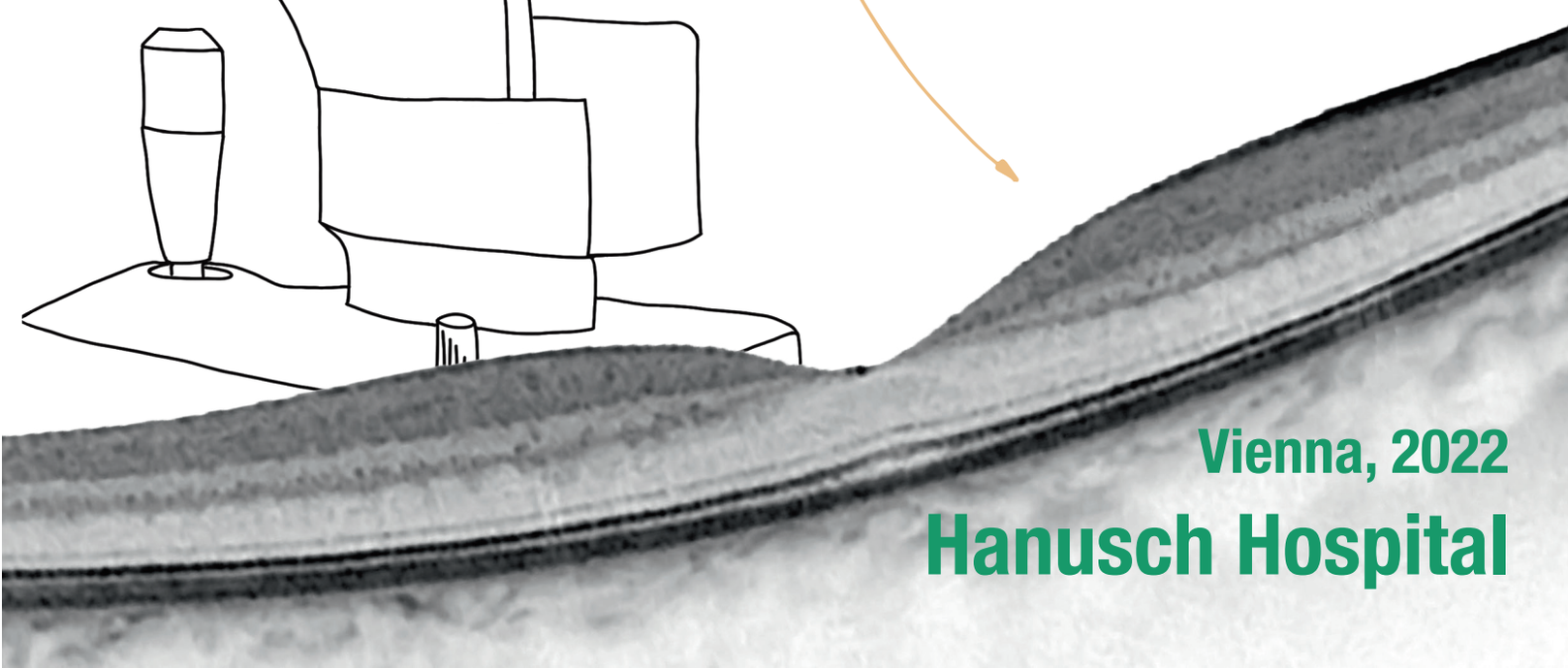
OCTraining

Michal Cieplucha
Josef Huemer
Stefan Palkovits
Oliver Findl

powered by

HEIDELBERG ENGINEERING ACADEMY





Vienna, 2022
Hanusch Hospital

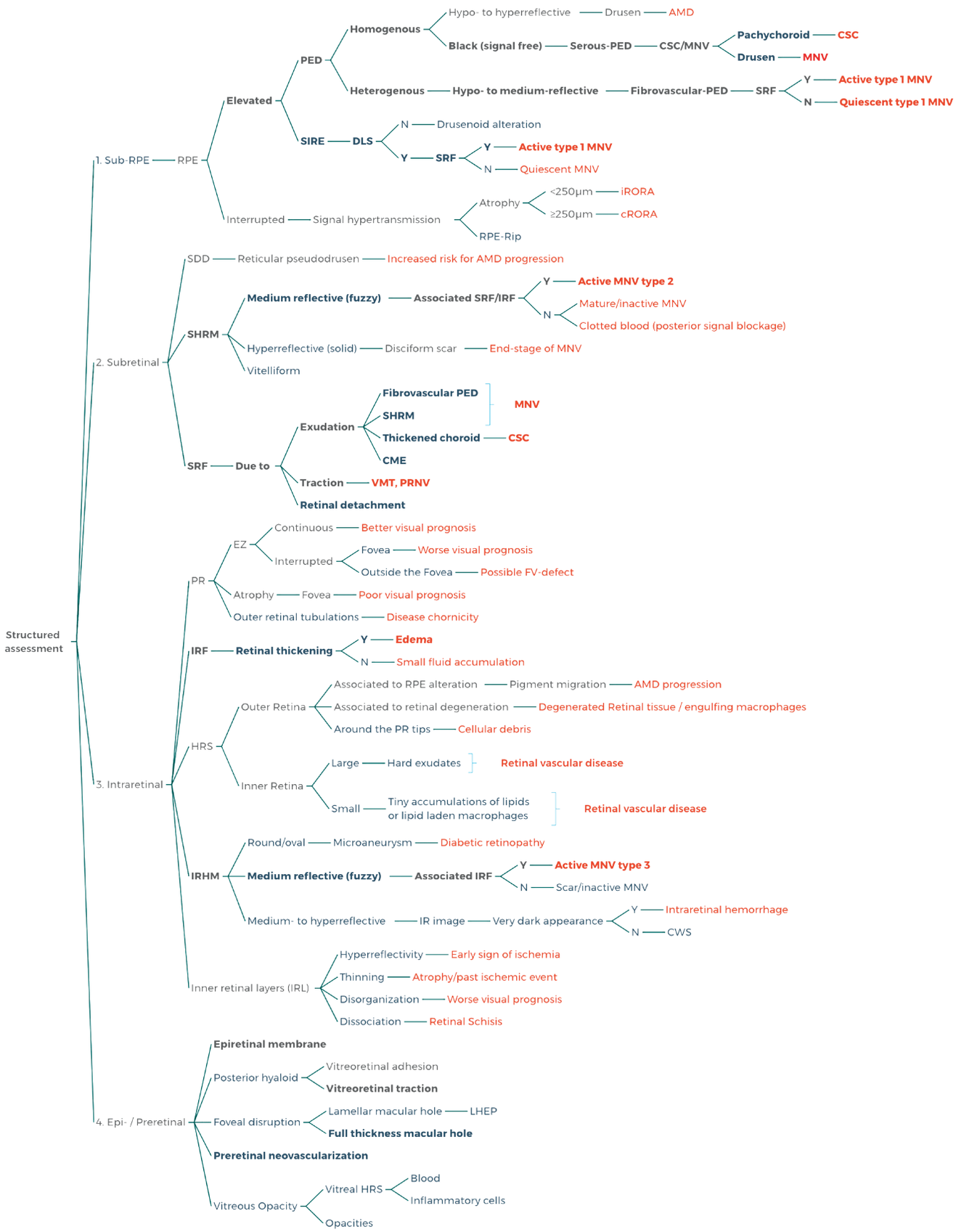
Use the two

Cheat Sheets!

Test Your Knowledge

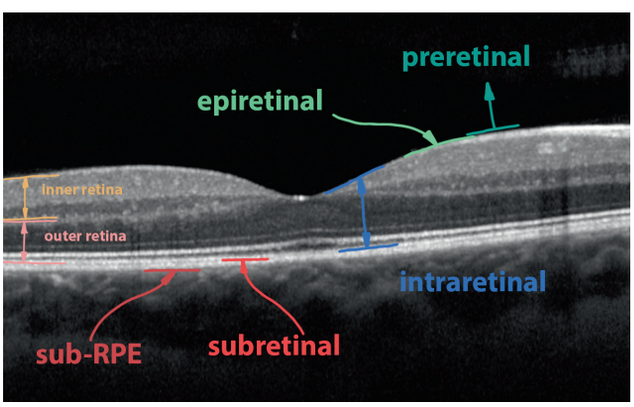
in the OCTraining Course Room!

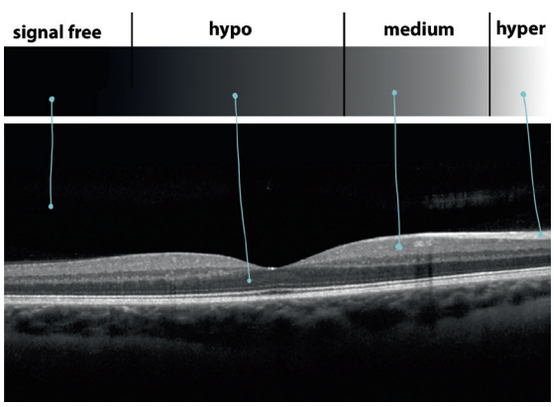
Assessment Guide

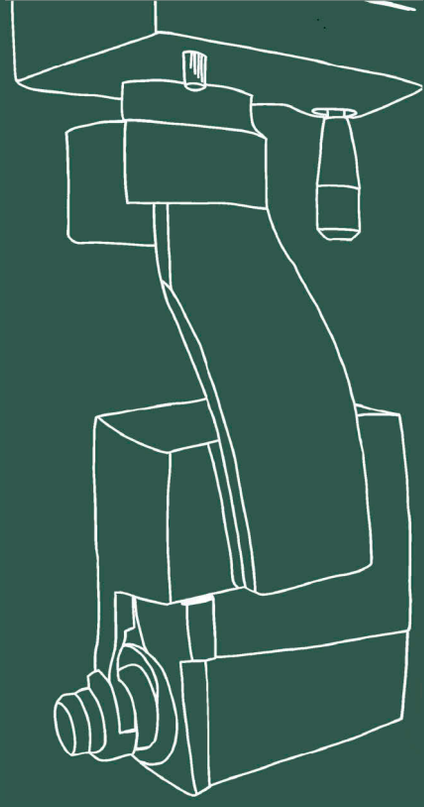


Abbreviations

AC	Amacrine Cells
AMD	Age-related Macular Degeneration
BCVA	Best Corrected Visual Acuity
BEM	Basement Membrane
BM	Bruch's Membrane
BPC	Bipolar Cells
BRVO	Branch Retinal Vein Occlusion
CC	Choriocapillaris
CFP	Color Fundus Photography
CWS	Cotton Wool Spots
CME	Cystoid Macular Edema
CNV	Choroidal Neovascularization
CRA	Central Retinal Artery
CRAO	Central Retinal Artery Occlusion
cRORA	Complete RPE and Outer Retinal Atrophy
CRVO	Central Retinal Vein Occlusion
CSC	Central Serous Chorioretinopathy
DLS	Double-layer Sign
DME	Diabetic Macular Edema
DR	Diabetic Retinopathy
DRIL	Disorganization of Retinal Inner Layers
ELM	External Limiting Membrane
ERM	Epiretinal Membrane
EZ	Ellipsoid Zone
EZ-f	Ellipsoid Zone Fragmentation
EZ-i	Ellipsoid Zone Interruption
FA	Fluorescein Angiography
F-PED	Fibrovascular PED
FTMH	Full-Thickness Macular Hole
GA	Geographic Atrophy
GCL	Ganglion Cell Layer
HC	Horizontal Cells
HIV	Human Immunodeficiency Virus
HFL	Henle Fiber Layer
HFL-RA	Henle Fiber Layer - Reflex Artifact
HRS	Hyperreflective Spots
HT	Hypertransmission
IHRM	Intraretinal Hyperreflective Material
INL	Inner Nuclear Layer
IPL	Inner Plexiform Layer
IRC	Intraretinal Cystoid Spaces
IR image	Infrared Image
IRF	Intraretinal Fluid
IRL	Inner Retinal Layers
iRORA	Incomplete RPE and Outer Retinal Atrophy
IZ	Interdigitation Zone
LHEP	Lamellar Hole-associated Epiretinal Proliferation
LMH	Lamellar Macular Hole
MA	Microaneurysm
MH	Macular Hole
MLM	Middle Limiting Membrane
MNV	Macular Neovascularization
MZ	Myoid Zone
nAMD	Neovascular AMD
OCT	Optical Coherence Tomography
OCTA	OCT Angiography
ONL	Outer Nuclear Layer
OPL	Outer Plexiform Layer
ORT	Outer Retinal Tubulation
PAMM	Paracentral Acute Middle Maculopathy
PCC	Prechoroidal Cleft
PCV	Polypoidal Choroidal Vasculopathy
PED	Pigment Epithelial Detachment
PH	Posterior Hyaloid
PM	Papillomacular
p-MLM	Prominent Middle Limiting Membrane
PR	Photoreceptor
PR-a	Photoreceptor Atrophy
PR-i	Photoreceptor Irregularity
PRNV	Preretinal Neovascularization
PR-OS	Photoreceptor Outer Segments
PVD	Posterior Vitreous Detachment
RAP	Retinal Angiomatous Proliferation
RD	Rhegmatogenous Detachment
RNFL	Retinal Nerve Fiber Layer
RPE	Retinal Pigment Epithelium
RPE-a	RPE Atrophy
RVO	Retinal Vein Occlusion
S-PED	Serous PED
S:N	Signal-to-Noise
SD-OCT	Spectral-Domain OCT
SDD	Subretinal Drusenoid Deposits
SHRM	Subretinal Hyperreflective Material
SIRE	Shallow, Irregular RPE Elevation
Signal-b	Signal Block
SRF	Subretinal Fluid
SS-OCT	Swept-Source OCT
TD-OCT	Time-Domain OCT
VA	Visual Acuity
VEGF	Vascular Endothelial Growth Factor
VF	Visual Field
VMA	Vitreomacular Adhesion
VMT	Vitreomacular Traction
VO	Vitreous Opacity
VRI	Vitreoretinal Interface

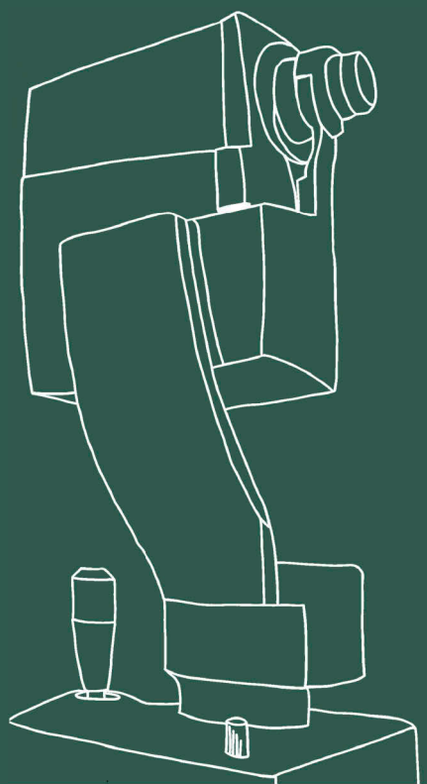






OCTraining

Cieplucha · Huemer · Palkovits · Findl



Imprint

Hanusch Hospital
Heinrich-Collin-Str. 30
1140 Vienna
Austria

Powered by
Heidelberg Engineering

210439-001 GL.AE22

Foreword

It is with great pleasure that I write the foreword to this extraordinary OCT book. It is extraordinary in several ways.

Firstly, it is didactically different from all OCT books I have held in hands. The original target audience were medical students with an interest in ophthalmology. But it turns out that this book is loved by trainees and many more experienced clinicians have found it to be invaluable, including me as an anterior segment and vitreoretinal surgeon with little exposure to medical retina. It is a mix between a basic introduction to the topic and a workbook with interesting cases that build confidence and develop skills for assessing OCTs.

Secondly, and for me even more extraordinary, the book was envisioned and written by one of our medical students, Michal Cieplucha. He came to our department during his last year in medical school for a 3-month clinical rotation in ophthalmology. He started in March 2020 just when the COVID-19 pandemic resulted in an historical global lockdown.
For this reason, he saw only few patients during his rotation and helped others prioritize and reschedule patients.

He chose to also use the time to go through our OCT image database and then, with the help of Josef Huemer, provided the images found in this book. Michal is not only a very enthusiastic medical student, but is altogether an innovative person interested in photography, production of podcasts, telemedicine and medical camps in Africa. I strongly recommend you visit his website www.cieplucha.de to get a better impression of Michal.

Lastly, this book is an example of international collaboration without financial interests. We received much support for proofreading by Prof. Michael Stur from Vienna, Drs. Mariana Lafetá, Eduardo Novaís from the Universidad Federal de Sao Paulo and Hagar Khalid from Moorfields Eye Hospital in London. One videocall with Heidelberg Engineering resulted in support for printing and distributing the book.

I hope you will enjoy the “playful” way of learning about OCT - please also try the online version which is even more interactive.

Oliver Findl

Acknowledgements

I am very grateful for all the support I received during this project! First, I would like to thank my co-authors, starting with Prof. Findl, who trusted me from the first moment and his love for detail was an important influence in the finalization of this project. Thanks to Josef Huemer, who shared my vision, supported me and was always available to answer my questions. Finally, through Stefan Palkovits' clinical experience, I learned not to dwell too long on too small details, and he also supported me selflessly despite his many responsibilities.

I would also like to thank the international team of retina specialists who have taken this project to a new level through their expansive knowledge and love for detail. Prof. Michael Stur (from Vienna, Austria) has contributed with his profound knowledge to the addition of many details and his support was an important motivator. Eduardo Novais (from Sao Paulo, Brazil) has contributed to a better understanding of pathophysiological processes, not only through his active support in this book but also through his tireless research work. The keen eye and excellent knowledge of Mariana Lafetá (from Sao Paulo, Brazil) and Hagar Khalid (from Egypt) have helped this project to come as far as it has.

I would like to thank the Heidelberg Engineering Academy for its commitment to high-quality, free education in this field for many years, who were an essential source of knowledge and inspiration for this book.

Finally, I would like to thank my partner Rosanna Hanke who has always supported me and listened to me all the way; without her, I would not have made it this far.

Author Affiliations

Michal Cieplucha, MD

Ophthalmology resident at University Clinic Düsseldorf
Research Fellow at Vienna Institute for Research in Ocular Surgery (VIROS), Hanusch Hospital, Dept. of Ophthalmology, Vienna

Josef Huemer, MD, FEBO

Consultant Ophthalmologist at Hanusch Hospital, Vienna
& Moorfields Eye Hospital, London

Stefan Palkovits, MD, FEBO, PhD

Consultant Ophthalmologist at Hanusch Hospital, Vienna

Prim. Univ-Prof. Oliver Findl, MD, MBA, FEBO

Director of the Dept. of Ophthalmology, Hanusch Hospital, Vienna
Founder and Head of the Vienna Institute for Research in Ocular Surgery (VIROS), Hanusch Hospital, Vienna

Contents

Abbreviations

AC	Amacrine Cells
AMD	Age-related Macular Degeneration
BCVA	Best Corrected Visual Acuity
BEM	Basement Membrane
BM	Bruch's Membrane
BPC	Bipolar Cells
BRVO	Branch Retinal Vein Occlusion
CC	Choriocapillaris
CFP	Color Fundus Photography
CWS	Cotton Wool Spots
CME	Cystoid Macular Edema
CNV	Choroidal Neovascularization
CRA	Central Retinal Artery
CRAO	Central Retinal Artery Occlusion
cRORA	Complete RPE and Outer Retinal Atrophy
CRVO	Central Retinal Vein Occlusion
CSC	Central Serous Chorioretinopathy
DLS	Double-layer Sign
DME	Diabetic Macular Edema
DR	Diabetic Retinopathy
DRIL	Disorganization of Retinal Inner Layers
ELM	External Limiting Membrane
ERM	Epiretinal Membrane
EZ	Ellipsoid Zone
EZ-f	Ellipsoid Zone Fragmentation
EZ-i	Ellipsoid Zone Interruption
FA	Fluorescein Angiography
F-PED	Fibrovascular PED
FTMH	Full-Thickness Macular Hole
GA	Geographic Atrophy
GCL	Ganglion Cell Layer
HC	Horizontal Cells
HIV	Human Immunodeficiency Virus
HFL	Henle Fiber Layer
HFL-RA	Henle Fiber Layer - Reflex Artifact
HRS	Hyperreflective Spots
HT	Hypertransmission
IHRM	Intraretinal Hyperreflective Material
INL	Inner Nuclear Layer
IPL	Inner Plexiform Layer
IRC	Intraretinal Cystoid Spaces
IR image	Infrared Image
IRF	Intraretinal Fluid
IRL	Inner Retinal Layers
iRORA	Incomplete RPE and Outer Retinal Atrophy
IZ	Interdigitation Zone
LHEP	Lamellar Hole-associated Epiretinal Proliferation
LMH	Lamellar Macular Hole
MA	Microaneurysm
MH	Macular Hole
MLM	Middle Limiting Membrane
MNV	Macular Neovascularization
MZ	Myoid Zone
nAMD	Neovascular AMD
OCT	Optical Coherence Tomography
OCT-A	OCT Angiography
ONL	Outer Nuclear Layer
OPL	Outer Plexiform Layer
ORT	Outer Retinal Tubulation
PAMM	Paracentral Acute Middle Maculopathy
PCC	Prechoroidal Cleft
PCV	Polypoidal Choroidal Vasculopathy
PED	Pigment Epithelial Detachment
PH	Posterior Hyaloid
PM	Papillomacular
p-MLM	Prominent Middle Limiting Membrane
PR	Photoreceptor
PR-a	Photoreceptor Atrophy
PR-i	Photoreceptor Irregularity
PRNV	Preretinal Neovascularization
PR-OS	Photoreceptor Outer Segments
PVD	Posterior Vitreous Detachment
RAP	Retinal Angiomatous Proliferation
RD	Rhegmatogenous Detachment
RNFL	Retinal Nerve Fiber Layer
RPE	Retinal Pigment Epithelium
RPE-a	RPE Atrophy
RVO	Retinal Vein Occlusion
S-PED	Serous PED
S:N	Signal-to-Noise
SD-OCT	Spectral-Domain OCT
SDD	Subretinal Drusenoid Deposits
SHRM	Subretinal Hyperreflective Material
SIRE	Shallow, Irregular RPE Elevation
Signal-b	Signal Block
SRF	Subretinal Fluid
SS-OCT	Swept-Source OCT
TD-OCT	Time-Domain OCT
VA	Visual Acuity
VEGF	Vascular Endothelial Growth Factor
VF	Visual Field
VMA	Vitreomacular Adhesion
VMT	Vitreomacular Traction
VO	Vitreous Opacity
VRI	Vitreoretinal Interface

Preface

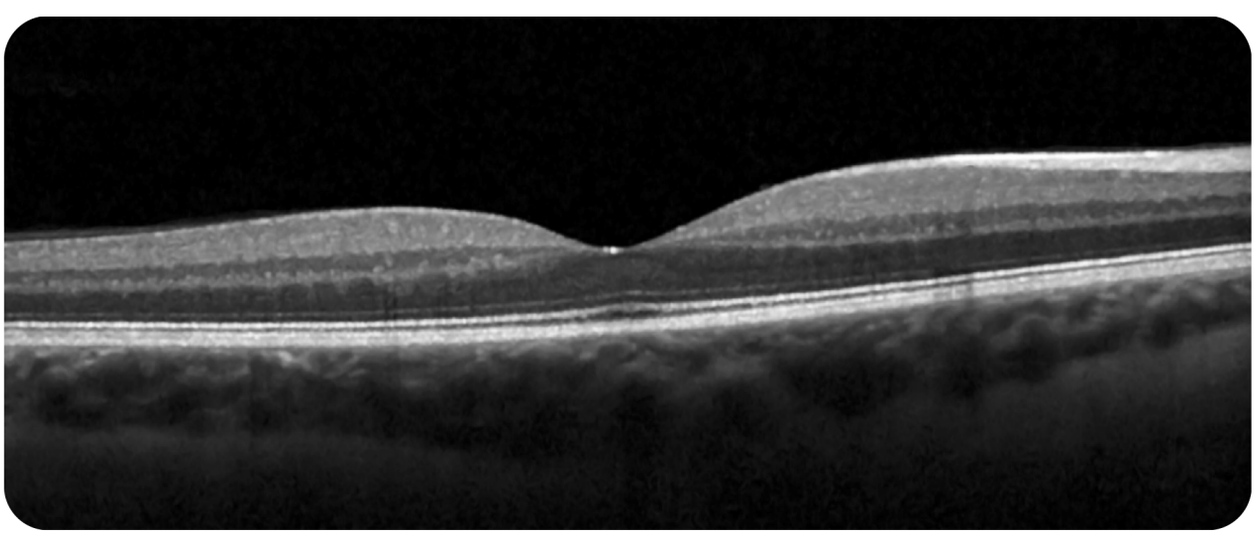
For the sake of training, imagine the following scenario:
You are in your examination room. A patient is at your clinic for the first time, and prior to the consultation, the photographer has acquired an OCT scan, as he would usually do. Before you even talk to the patient, you will review the scan just to have an idea of what awaits you – purely retinal.

This book teaches you to perform a detailed assessment and interpretation of an OCT scan, and like the scenario described above, the book only consists of IR images and cross-sectional OCT scans, with no further imaging modalities included. This will help you to understand the limitations of what seems a limitless diagnostic tool.

You will learn OCT-relevant anatomy, physiology, and pathophysiology in the first two chapters of this book, and the exercise part will provide you with OCT scans of common retinal conditions you may see in your daily practice. Every blank scan is followed by a detailed assessment with colored markings of the alterations.

The goal is to precisely describe the retinal condition you see in the picture; this will allow you to narrow down the differential diagnoses and decisively plan further diagnostic procedures.

Author's recommendation:
Depending on your level of knowledge, you can work with this book in two ways. For beginners, we would recommend starting with chapter 1 and working your way to the exercise section (Chapter 3). However, if you already have some experience, it might be more fun jumping straight to the exercise part to test your skills and only review the theory-part of this book as needed.



(Fig. 1) Single OCT section image of the healthy retina

1.1 Optical Coherence Tomography (OCT)

1. Preparation

1.1 Optical Coherence Tomography (OCT)

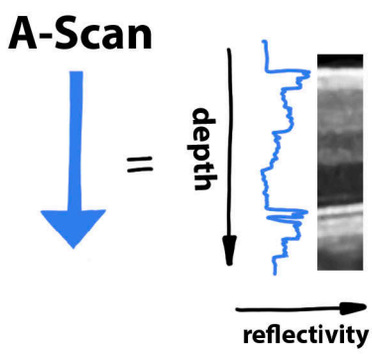
When optical coherence tomography (OCT) was first introduced back in 1991[1], it revolutionized ophthalmic practice, as it enables us to obtain a microscopic, anatomically accurate cross-sectional image of the retina (Fig. 1). It was the perfect addition to the already existing examination methods and over the years, it became an essential tool for the retina specialist, enabling early diagnosis, enhanced therapy monitoring, and a better understanding of retinal pathologies[2].

The basic principle underlying the OCT is interferometry, where light waves' interference is used to measure distances[3]. Each layer of the retina is composed differently – while the outer nuclear layer (ONL) (Fig. 2) consists of the photoreceptor's cell bodies, one will only find parallel running axons of the ganglion cells in the retinal nerve fiber layer (RNFL) (covered in 1.2.1 Retinal Architecture). These differences result in different optical properties and thus reflective behavior, allowing us to visualize the individual retinal layers using OCT technology.

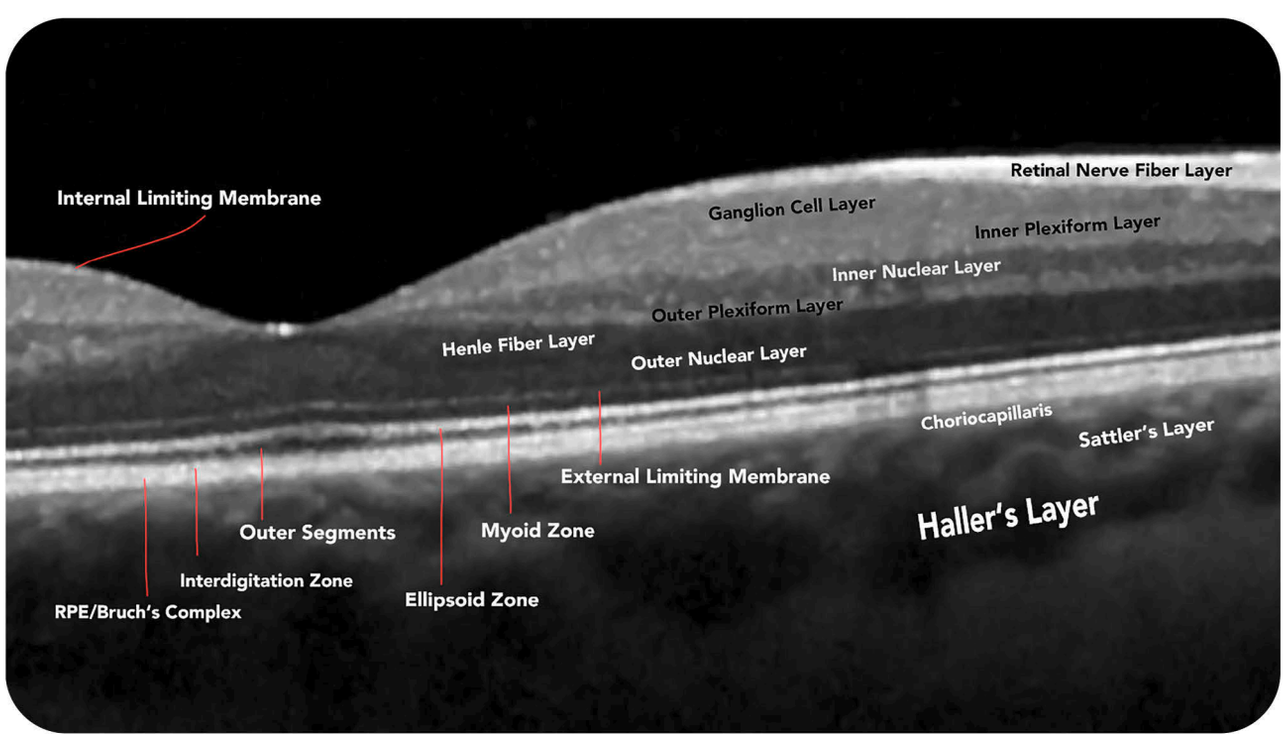
The first commercially available technology, the time-domain OCT (TD-OCT), had moving components that limited the resolution and the acquisition speed. With the development of modern, spectrally distinct detectors (spectral-domain OCT; SD-OCT) and complex light sources (swept-source OCT; SS-OCT), scan speeds and resolution were vastly improved[4].

All images presented in this book were acquired at the Hanusch Hospital in Vienna, with a SPECTRALIS® OCT (Heidelberg Engineering), which uses spectral domain technology, allowing fast scan speeds and a maximum axial resolution of 7 µm[5].

When acquiring, the OCT device sends out multiple light waves. The light is reflected from the different retinal layers and is then detected and computed by the device into a reflectivity versus depth curve. This information is transformed into a greyscale image, which results in an A-scan (Fig. 3). Multiple A-scans are then stitched together to form a B-scan or cross-sectional scan (Fig. 1). The higher the number of A-scans per millimeter, the more detailed is the cross-sectional scan[6].



(Fig. 3) A-scan – reflectivity vs. depth curve



(Fig. 2) Labeled section image of a healthy retina.

1.2 The Healthy Choroid and Retina

1.2.1 Retinal Architecture (Fig. 5)

Starting at the very bottom of an OCT scan, the first structure one comes across is a mosaic-like formation composed of hyporeflective circles and ovals, representing the vessels of the choroid (Fig. 2).

Choroid

The choroid, which is the main supplier of oxygen for the outer retina[7], is divided into three layers in the OCT: the Haller's layer with its large vessels, the Sattler's layer with the smaller arterioles and venules, and lastly, the choriocapillaris, containing the capillaries of the choroid[8] (Fig. 2).

Retinal Pigment Epithelium (RPE)

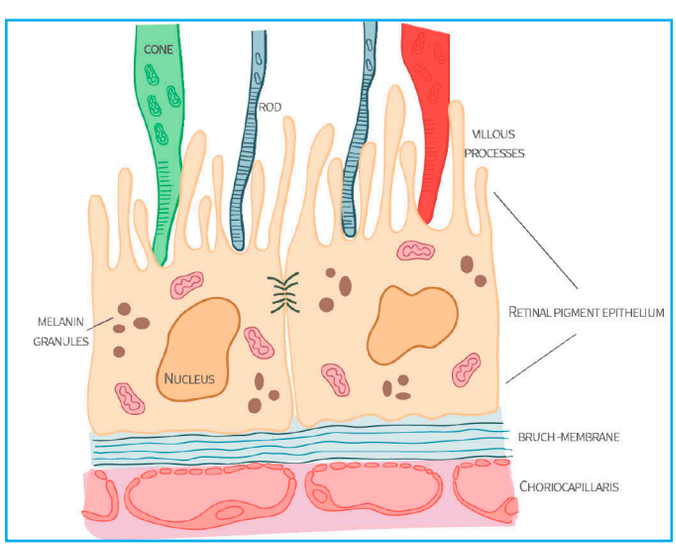
The outermost hyperreflective band within the OCT represents the RPE-Bruch's membrane complex. The RPE cells, which are based on the Bruch's membrane, are interconnected by tight junctions and form the outer blood-retinal barrier (Fig. 4). They have a wide variety of functions, with the most important for the understanding of structural changes in the OCT being[9]:

- the phagocytosis of photoreceptor outer segments (PR-OS),
- the active transportation of nutrients and ions to the photoreceptors (PR),
- the maintenance of the outer blood-retinal barrier,
- the absorption of light, and
- the maintenance of the retinal adhesion through its villous processes.

The photoreceptors are only loosely attached to the RPE, with no real intercellular connections.

Photoreceptor (PR)

The photoreceptors (PR) pass through several layers within an OCT scan (Fig. 5), reaching from the interdigitation zone (IZ, hyperreflective band), where the PRs connect to the RPE up to the outer plexiform layer (OPL), where the light signals are transmitted to the bipolar cells[8] (Fig. 7).



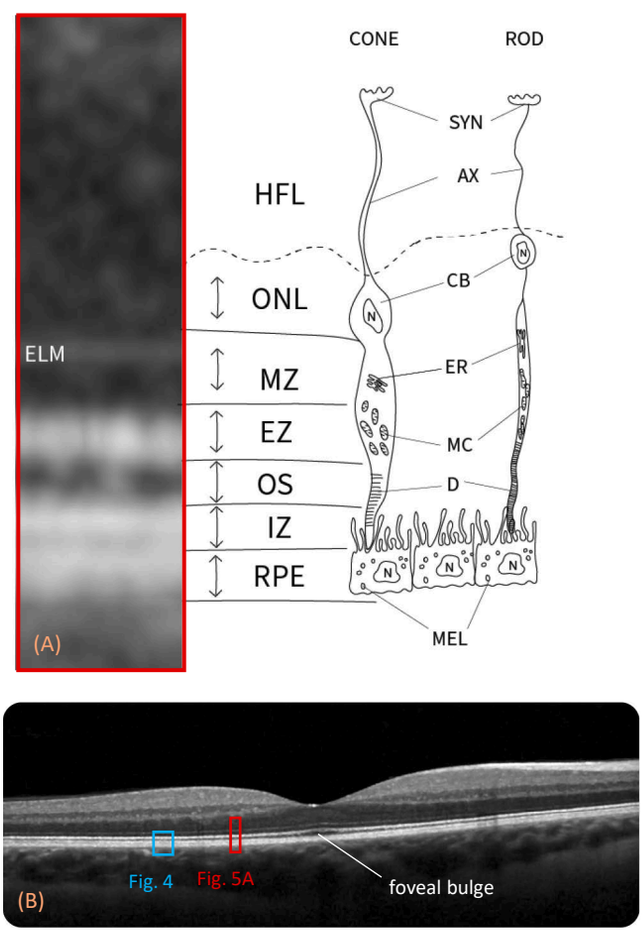
(Fig. 4) Bruch's membrane is a multilayered membrane of collagenous tissue and consists amongst others of the basement membranes of the retinal pigment epithelium and the choriocapillaris.

The photoreceptor outer-segments (hyporeflective band) contain up to 1000 laminated discs with light-sensitive molecules, which, once activated, are shed, phagocytized, and recycled by the RPE[9].

There are two different types of PRs (rods and cones) with different counts, functions, and distributions. The cone PRs (approx. 6 mio.) are mainly located within the macula, with the highest density right at the fovea (forming the foveal bulge (Fig. 5)). They are responsible for color and fine-detail vision. On the other hand, rods (approx. 125 mio.) are spread across the whole retina except for the fovea, which is free of rods. Among other functions, they enable us to see under mesopic conditions.

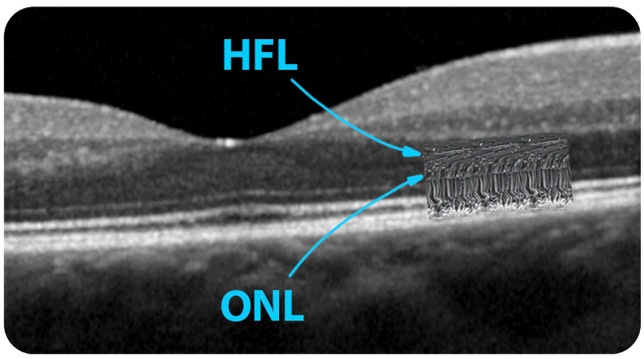
The ellipsoid zone (EZ) of the PRs contains all the cell's mitochondria, and the myoid zone includes the endoplasmic reticulum, the Golgi apparatus, and ribosomes[10]. At the external limiting membrane (ELM), the glial Müller cells connect to the PRs (Fig. 7); it is not an actual membrane, and it is highly permeable for nutrients from the choroidal blood flow.

The hyporeflective layer next to the ELM is divided into two parts, the outer nuclear layer (ONL) and the Henle fiber layer (HFL) (Fig. 6); the ONL contains the PR cell bodies with their nuclei, and the HFL consists of PR axons[8,9,11].



(Fig. 5) (A): The ultrastructure of a cone and rod photoreceptor and its location within an OCT scan. RPE: Retinal Pigment Epithelium, IZ: Interdigitation Zone, OS: Outer Segment, EZ: Ellipsoid Zone, MZ: Myoid Zone, ONL: Outer Nuclear Layer, HFL: Henle Fiber Layer. N: Nucleus, ELM: External Limiting Membrane, SYN: Synapse, AX: Axon, CB: Cell Body, ER: Endoplasmatic Reticulum, MC: Mitochondria, D: Disc, MEL: Melanocytes; (B): The blue box refers to (Fig. 4) and the red box to Fig.5A, The foveal bulge represents the concentration of cone photoreceptors in the fovea.

1.2.1 Retinal Architecture



(Fig. 6) Henle fiber layer and outer nuclear layer

Signal Transmission

Outer Plexiform Layer (OPL)

In the following layer, the outer plexiform layer (OPL), the signal is transmitted from the PRs to the bipolar cells (BPC) and horizontal cells (HC) (Fig.7). It represents the interconnections between the PRs' axons, BPC, and HC dendrites[8]. Fluid-filled spaces usually do not break the OPL but form on each side of it. Right at the fovea, the inner retinal layers are displaced laterally, allowing the light to fall directly onto the PRs. There is a 1:1 ratio of signal transmission from the PRs to BPCs, enabling the highest spatial resolution and, thus, the sharpest vision. This ratio loosens towards the periphery, where sometimes over 100 PRs connect to one BPC[9].

Inner Nuclear Layer (INL)

The inner nuclear layer (INL) contains the bipolar, horizontal, and amacrine cells (AC) cell bodies (Fig. 7).

Inner Plexiform Layer (IPL)

In the inner plexiform layer (IPL), the BPCs and ACs axons interconnect with the ganglion cells' dendrites (Fig. 7).

Ganglion Cell Layer (GCL)

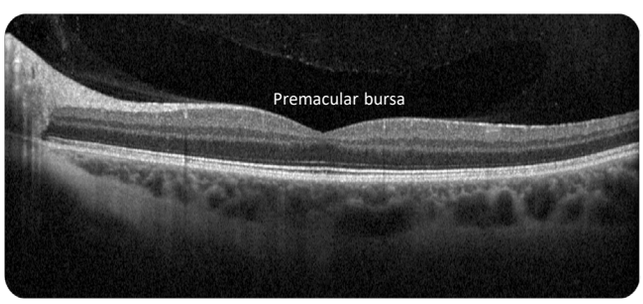
The ganglion cell layer (GCL) contains the ganglion cells' cell bodies, and the retinal nerve fiber layer consists of their axons[12]. The whole retina consists of around 130 million PRs, and only 1.2 million GC axons that leave the eye through the optic nerve, leading to the lateral geniculate nucleus of the brain[13].

Internal Limiting Membrane (ILM)

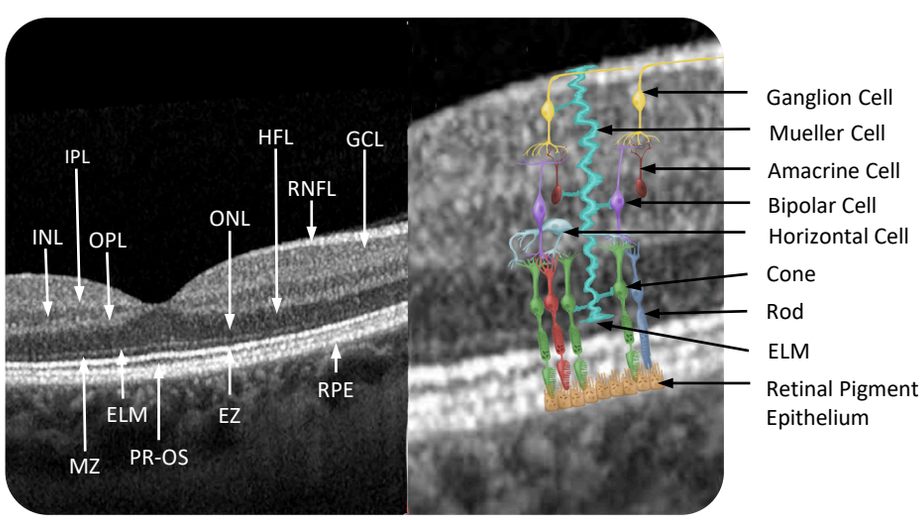
Anteriorly the retina is bordered by the inner limiting membrane (ILM), which, similarly to the ELM, is formed by the footplates of the Mueller cells[12] (Fig. 2).

Vitreous

Anterior to the RNFL lies the vitreous, a gel-like structure consisting of collagen, hyaluronan and 98–99% of water, making up 80% of the eyes' volume[14]. In standard OCT imaging, the vitreous appears as a black space (no signal) due to its highly transparent nature. The vitreous is firmly attached to the vitreous base, the posterior lens capsule, the papilla, along the retinal vessels, as well as the fovea and macula[14]. Using enhanced vitreous imaging modes, which are available in most modern OCT devices, it is possible to even better display its collagenous structure and anatomical features, such as the premacular bursa (Fig. 8) – a fluid-filled pocket anterior to the macula.



(Fig. 8) Visualization of the premacular bursa using an enhanced vitreous imaging mode.



(Fig. 7) The signal transmission in the retina: RPE: Retinal Pigment Epithelium, IZ: Interdigitation Zone, PR-OS: Photoreceptor Outer Segments, EZ: Ellipsoid Zone, MZ: Myoid Zone, ELM: External Limiting Membrane, ONL: Outer Nuclear Layer, HFL: Henle Fiber Layer, OPL: Outer Plexiform Layer, INL: Inner Nuclear Layer, IPL: Inner Plexiform Layer, GCL: Ganglion Cell Layer, RNFL: Retinal Nerve Fiber Layer

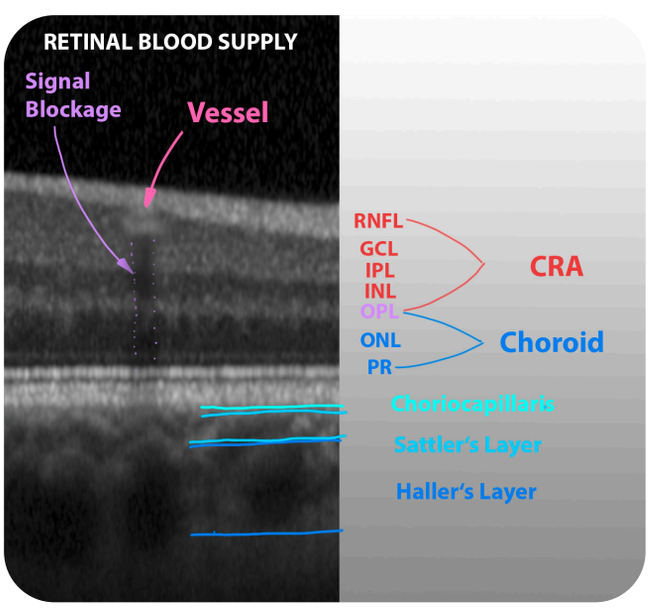
1.2.2 Retinal Blood Supply

The retina is supplied with oxygen and other nutrients by two blood circulations: the choroidal blood circulation, which supplies the outer third of the retina, and the retinal blood circulation, which supplies the inner two-thirds (Fig. 9). In some cases, there are bridging chorioretinal vessels that interconnect the two systems.

Choroidal Blood Circulation

As mentioned previously, the choroid can be divided into three layers: the Haller's layer with large vessels, the Sattler's layer with smaller arterioles and venules, and lastly, the choriocapillaris that contains the capillaries of the choroid[8] (Fig. 10). In relation to the organ size, the retinal tissue has the highest demand for oxygen from all bodies' tissues. About 90% of all the retinas' oxygen is supplied from the choroidal blood flow, and most of it is consumed by the photoreceptors[7].

The capillaries of the choroid have a fenestrated endothelium with the gaps facing towards the Bruch's membrane[15] (Fig. 4). The tight junctions that interconnect the RPE cells form the outer blood-retinal barrier, allowing only oxygen and other small molecules to pass. With its multilayered ultrastructure, Bruch's membrane borders the RPE and the choroid. It consists, amongst other layers, of the basal laminas of both the RPE and the capillaries of the choroid[9] (Fig. 4). No matter what the underlying condition is, a break in the Bruch's membrane may lead to choroidal neovascularization[16,17], which is discussed in detail, in the chapter “2.5.4 Macular Neovascularization - Summary”, later in this book.

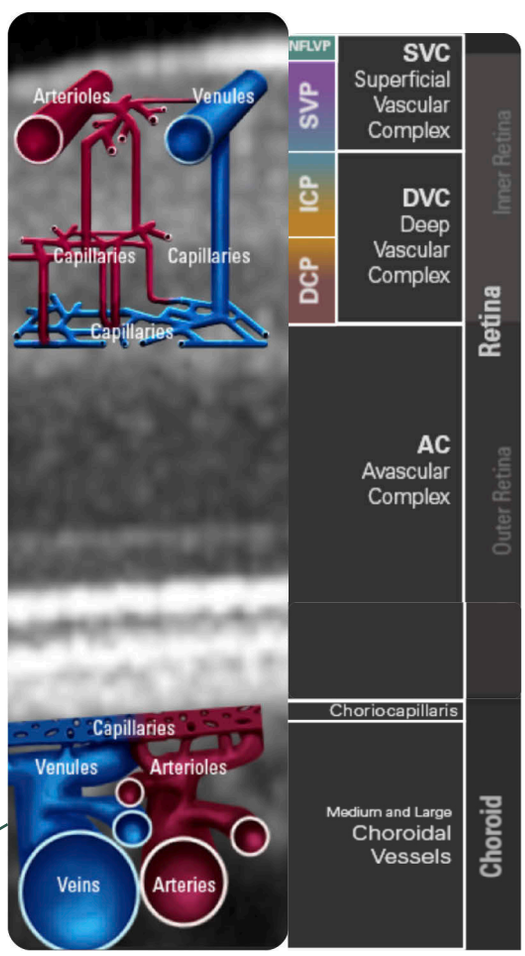


(Fig. 9) Area of supply from the two retinal blood circulations. CRA: central retinal artery. The vessel is blocking the light signals, causing a shadowing artifact. RNFL: Retinal Nerve Fiber Layer, GCL: Ganglion Cell Layer, IPL: Inner Plexiform Layer, OPL: Outer Plexiform Layer, ONL: Outer Nuclear Layer, PR: Photoreceptors

Central Retinal Blood Circulation

The central retinal artery (CRA) subsequently divides into four major branches when leaving the optic disc: the superior and inferior, temporal and nasal arcades. Following their course, the arteries split into arterioles and ultimately into capillaries, forming four capillary beds within the retina's inner layers (Fig. 8). The innermost, also called radial peripapillary plexus, lies within the RNFL and supplies it with oxygen and nutrients. The superficial-, intermediate-, and deep-capillary plexus lie within the GCL, the inner half of the INL, and the outer half of the INL, respectively (Fig. 11). On a cellular level, the retinal capillaries have a non-fenestrated endothelium (like cerebral capillaries), only allowing oxygen and other small molecules to pass, thus forming the inner blood-retinal barrier. Diseases compromising this blood-retinal barrier, e.g., diabetic retinopathy (DR), may lead to leakage of fluid and lipoproteins into the retina, causing edema and the formation of so-called hard exudates (covered in chapter 2.5.4 Intraretinal Area – Hyperreflective Spots). Finally, the venous blood is collected by the branch veins that merge into the central retinal vein.

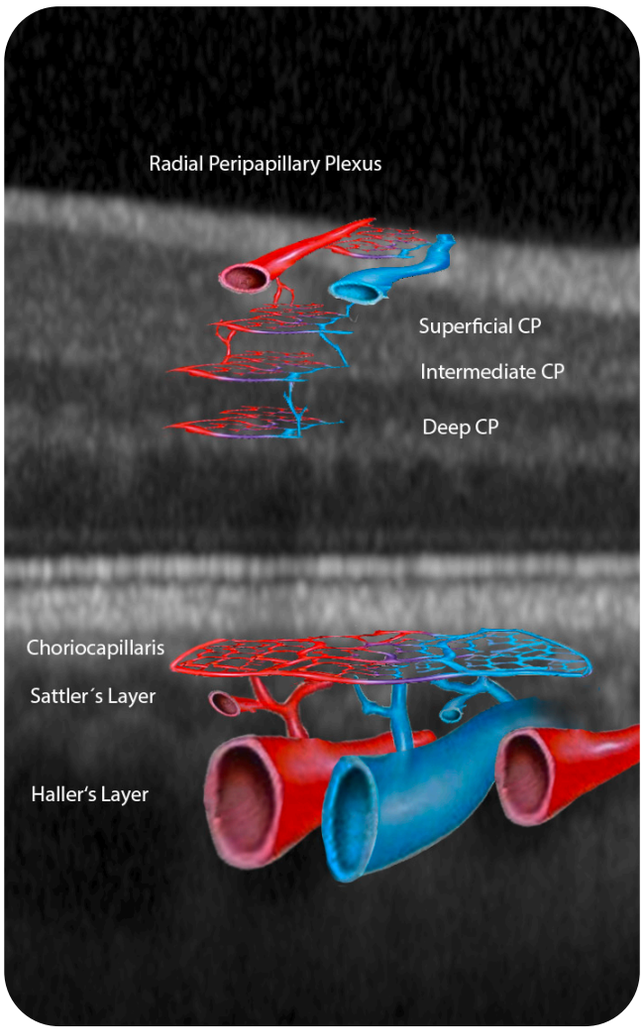
In an OCT scan, the retinal vessels appear as round, medium reflective formations, that are causing a posterior signal blockage (Fig. 9) – when in doubt during the assessment, look at the green line in the IR image to see if it crosses any retinal vessels.



(Fig. 10) 3D representation of the choroidal and central retinal blood supply. SVP: Superficial Vascular Plexus, ICP: Intermediate Capillary Plexus, DCP: Deep Capillary Plexus

Check out the interactive version
(Retinal Layers *interactive*).

1.2.2 Retinal Blood Supply



(Fig. 11) Another representation of the blood supply showing all four capillary beds. CP: Capillary Plexus

References

1. Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography. Science. 1991;254(5035):1178-1181.
2. Wibbelsman TD, Pandit RR, Xu D, et al. Trends in retina specialist imaging utilization from 2012 to 2016 in the United States Medicare fee-for-service population. American journal of ophthalmology. 2019;208:12-18.
3. Coscas G, Lupidi M, Coscas F. Heidelberg Spectralis Optical Coherence Tomography Angiography: Technical Aspects.
4. Ma Z, Wang RK, Zhang F, Yao J. High-speed spectral domain optical coherence tomography for imaging of biological tissues. Paper presented at: Optics in Health Care and Biomedical Optics: Diagnostics and Treatment II2005.
5. Puzyeyeva O, Lam WC, Flanagan JG, et al. High-resolution optical coherence tomography retinal imaging: a case series illustrating potential and limitations. Journal of ophthalmology. 2011;2011.
6. van Velthoven ME, Faber DJ, Verbraak FD, van Leeuwen TG, de Smet MD. Recent developments in optical coherence tomography for imaging the retina. Progress in retinal and eye research. 2007;26(1):57-77.
7. Ahmed J, Braun R, Dunn R, Linsenmeier RA. Oxygen distribution in the macaque retina. Investigative ophthalmology & visual science. 1993;34(3):516-521.
8. Staurenghi G, Sadda S, Chakravarthy U, Spaide RF. Proposed lexicon for anatomic landmarks in normal posterior segment spectral-domain optical coherence tomography: the IN• OCT consensus. Ophthalmology. 2014;121(8):1572-1578.
9. BCSC: Basic and Clinical Science Course: Section 12. American Academy of Ophthalmology; 2019.
10. Spaide RF, Curcio CA. Anatomical correlates to the bands seen in the outer retina by optical coherence tomography: literature review and model. Retina (Philadelphia, Pa). 2011;31(8):1609.
11. Gupta MP, Herzlich AA, Sauer T, Chan CC. Retinal Anatomy and Pathology.
12. Freund KB, Sarraf D, Mieler WF, Yannuzzi LA. The Retinal Atlas E-Book. Elsevier Health Sciences; 2016.
13. Tovée MJ. An introduction to the visual system. Cambridge University Press; 1996.
14. Sebag J. Vitreous: in health and disease. Springer; 2014.
15. Lutty G, Hasegawa T, Baba T, Grebe R, Bhutto I, McLeod D. Development of the human choriocapillaris. Eye. 2010;24(3):408-415.
16. Campochiaro PA. Retinal and choroidal neovascularization. Journal of cellular physiology. 2000;184(3):301-310.
17. D'Amore PA. Mechanisms of retinal and choroidal neovascularization. Investigative ophthalmology & visual science. 1994;35(12):3974-3979.

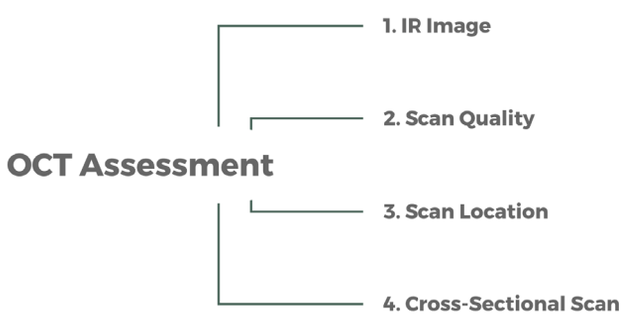
List of Figures

2. OCT Assessment

2.1 Introduction

OCT is a depth-resolved image modality; thus, its interpretation should be performed layer by layer.

This chapter will explain all the steps of an OCT assessment (Fig. 1) in detail, beginning with a brief overview. We recommend starting the OCT assessment with an evaluation of the infrared image (IR image) (Fig. 2), which is automatically acquired with each OCT scan when using the Heidelberg Engineering SPECTRALIS® OCT. The infrared (IR) image provides an excellent overview of the central retina and can help elucidate differential diagnoses. The next step is the scan quality assessment, where you should recognize artifacts and decide whether the quality is acceptable for the assessment. Then it is essential to identify the scan location because, while extrafoveal changes usually lead to corresponding visual field (VF) defects, the alterations of the retinal tissue at the fovea can reduce the patients' visual acuity (VA) and lead to central scotomas.



(Fig. 1) Structured process of the OCT assessment.

You should start the assessment of the cross-sectional scan at the RPE layer and continue from there. Writing down all the alterations you find in the scan often eases the process – continue with the intraretinal and preretinal area. Once all morphological changes have been identified, you can make a precise interpretation.

With this technique, you will be able to assess any retinal condition, practicing with the most common ones in this book.

2.2 Infrared (IR) Image

2.2 Infrared (IR) Image

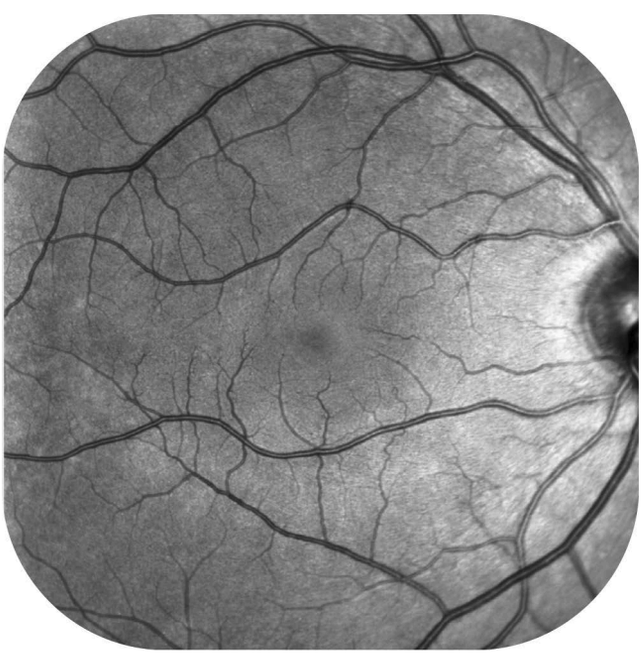
The IR image offers an excellent overview of the extent of retinal alterations and might give you a hint about the underlying disease. An alteration on the IR image is very likely to reveal a morphological change in the cross-sectional scan, and both images supplement each other nicely.

In a healthy patient, the IR image has a smooth monotone appearance and an evident foveal depression (Fig. 2). Soft gradients from light to dark as well as a lighter appearance of the peripapillary region can also occur in healthy individuals and can be considered normal.

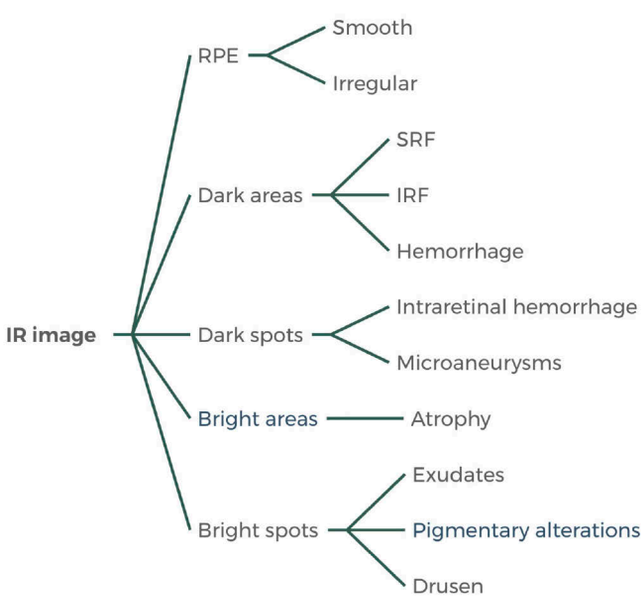
Dark areas signify light absorption, resulting from any fluid (Fig. 4A) or blood (Fig. 4B, D) accumulation in the sub RPE, subretinal, intraretinal, or epiretinal space. While round and sharply demarcated hyporeflective spots often represent microaneurysms (MA) (Fig. 4C), blurred, flame-like alterations (Fig. 4D) represent retinal hemorrhages.

Bright spots are signs of increased reflectivity usually caused by exudates (Fig. 4E). However, drusen (Fig. 4F, H) or pigmentary alterations (Fig. 4I) might also have a hyperreflective appearance – you can easily distinguish them by their location and appearance on the cross-sectional scan. Areas of RPE atrophy appear bright, often with a visualization of the underlying choroidal vessels (Fig. 4G).

As drusen have variable looks, from hyper- to hyporeflective (Fig. 4F vs. Fig. 4H), an irregular appearance, especially in the macular region, is suspect of drusen, which must be verified on the cross-sectional scan. The IR image has shown to be particularly helpful for detecting subretinal drusenoid deposits (SDD) also called reticular pseudodrusen (both terms are used synonymously in this book). They often appear as a network of medium to hyperreflective alterations with a hyporeflective halo (Fig. 4I).



(Fig. 2) IR image of a healthy retina.

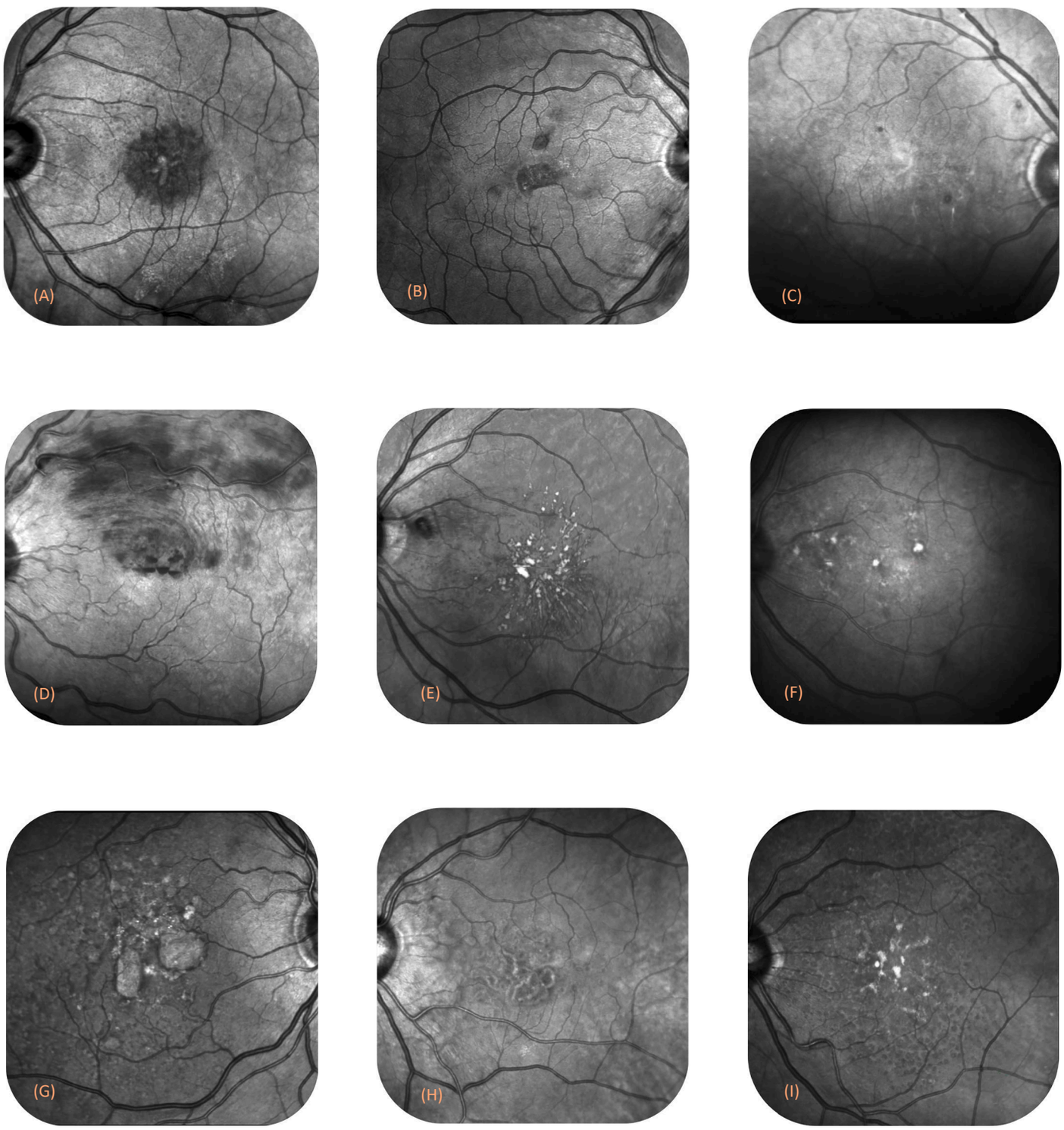


(Fig.3) IR image – assessment guide

Reticular means netlike and describes the appearance of reticular pseudodrusen in the IR image. Subretinal drusenoid deposits on the other hand is a newer term for the same alteration matching the subretinal localization in the OCT scan.

2.2 Infrared (IR) Image

IR Image Examples



(Fig.4) (A) dark area with a central petaloid pattern (classic in cystoid macular edema), (B) hyporeflective areas representing epiretinal blood accumulations, (C) two round hyporeflective dots representing micro aneurysms, the image is unevenly illuminated, (D) flame-shaped hyporeflective areas representing intraretinal hemorrhages, (E) white hyperreflective spots representing hard exudates, arranged in a star-like formation called circinate figure, (F) hyperreflective spots representing colloid drusen, the image presents a vignetting artifact (G) hyperreflective areas with visualized choroidal vessels representing areas of geographic atrophy, (H) hyporeflective areas with a hyperreflective ring, representing large drusen, (I) central hyperreflective alterations represent pigment clumping/migration; the tiny, reticular (networked) medium reflective alterations with a hyporeflective halo represent reticular pseudodrusen and are mainly spread in the peripheral macula, sparing the central area.

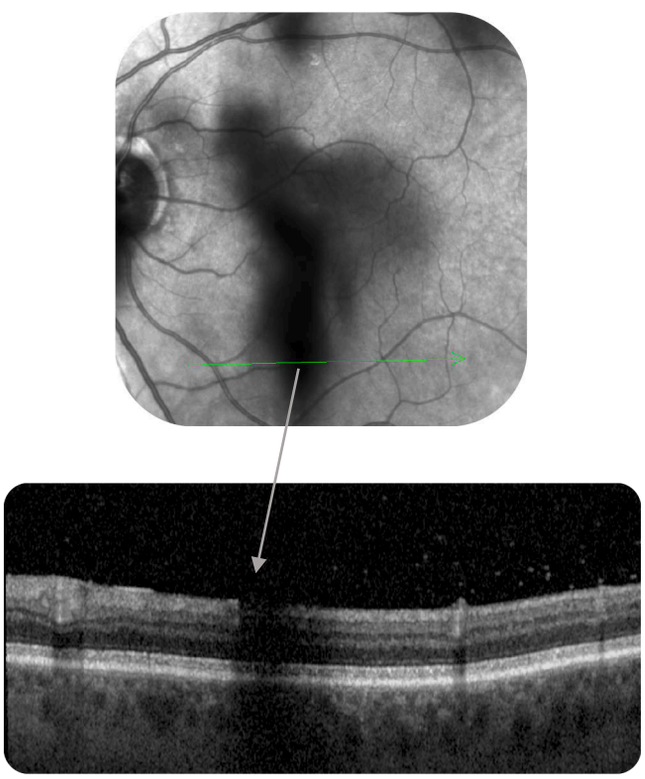
2.3 Scan Quality

2.3 Scan Quality

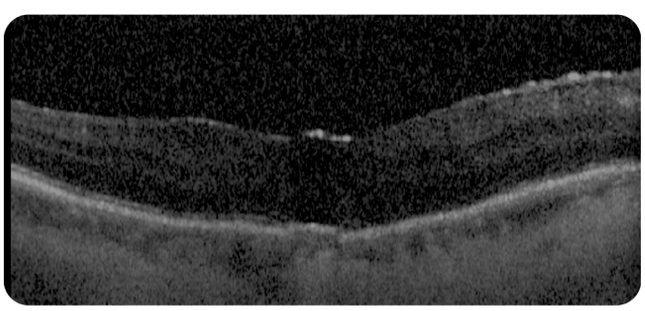
When referring to scan quality in this book, we are evaluating the signal-to-noise (S:N) ratio. For convenience, we rated the scan quality as either “good,” “noisy”, or “insufficient”.

“Good” image quality means the scan offers a sufficient resolution of details with a high S:N ratio (Fig. 1 in Chapter 1). Conversely, when the S:N ratio decreases, but details can still be evaluated – this is when we refer to a scan as “noisy”. Lastly, the scan quality is “insufficient” when you must guess whether there is an alteration in the area of interest (Fig. 6).

While opacities of the cornea or lens can lead to a reduced scan quality by affecting the S:N ratio (Fig. 6), vitreous opacities (VO) usually cast shadow artifacts but do not influence the resolution or S:N ratio (Fig. 5).



(Fig. 5) IR image: the black cloud represents a vitreous opacity (VO). OCT: shadowing artifact caused by the VO.



(Fig. 6) Insufficient scan quality (caused by a cataract) for the assessment of retinal alterations

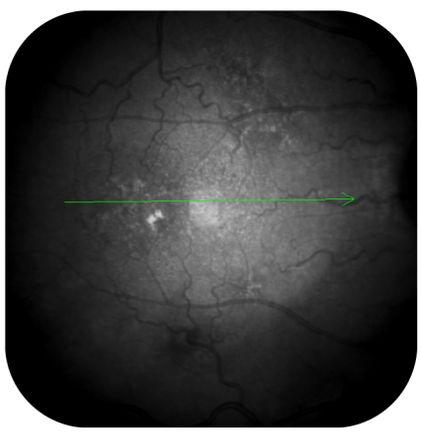
If you move the OCT camera too close to the patient’s eye, it will lead to a mirror artifact (Fig. 8) that occurs as the area of interest crosses the zero-delay line; this can also happen in ocular conditions such as retinoschisis (Fig. 8), retinal detachment, or high myopia.

Blink and motion artifacts usually no longer occur with new SD-OCT devices, due to the modern eye-tracking software.

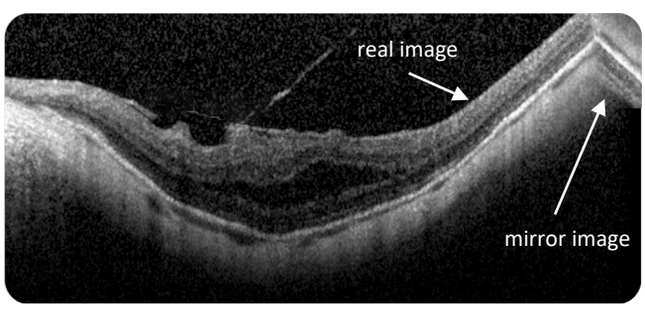
However, a common artifact is the vignetting artifact that occurs when the iris is blocking a part of the image – this could be either due to a tiny pupil opening or when the OCT camera is too far away from the eye (Fig. 7). In this case, the IR image appears to be unevenly illuminated and parts of the cross-sectional scan might be blocked or have a reduced S:N ratio.

The IR image must be evenly illuminated, without dark corners, and the focus must be set on the vessels at the area of interest (Fig.2).

Our standard OCT settings for image acquisition of the images in the exercise part were:
Application & Structure**:** Retina
Scan**:** 20°x20° Volume scan, Density 240 µm, 25 sections, ART frames: 9 – which results in about 768 A-scans.



(Fig. 7) Vignetting artifact



(Fig. 8) Mirror artifact

2.4 Scan Location

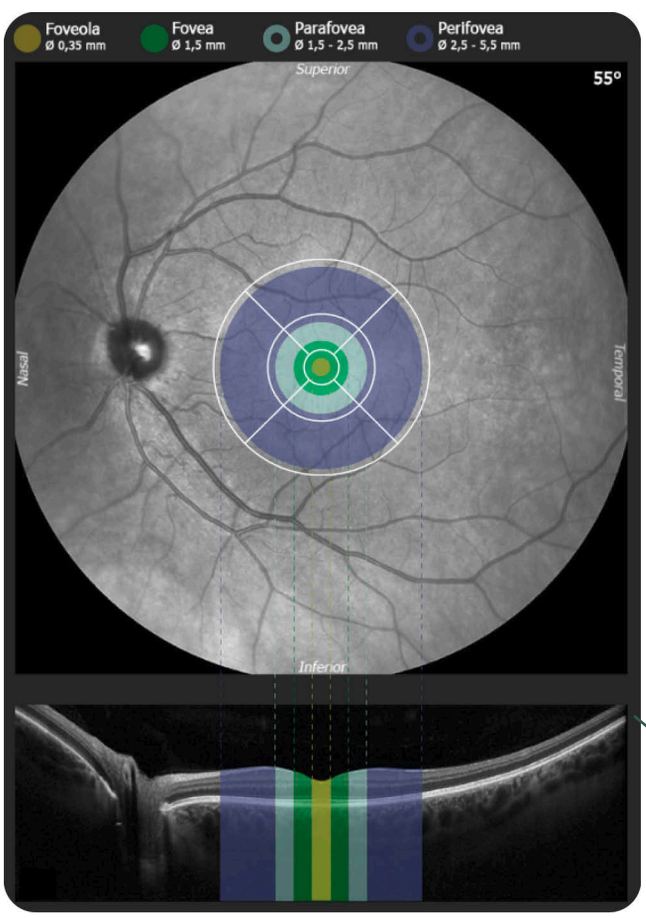
Clinically, the macula is a round area, with a diameter of approximately 5.5 mm, located between the optic nerve head and the temporal vascular arcades (Fig. 9). On a histologic level, the macula is where the retina has two or more layers of GC bodies. In the center of the macula lies the fovea (area of sharpest vision) with the foveola, the point of sharpest vision, right in the middle. Here the inner retinal layers are displaced laterally, allowing the light to fall directly onto the PRs, reducing the risk for aberrations. The fovea is surrounded by the para- and perifoveal areas.

2.4.1 Landmarks

Fovea

The foveal depression (or pit) can be identified on OCT by following the RNFL and OPL layers – the fovea is where these layers merge (Fig. 11). Furthermore, the foveal bulge represents the concentration and high density of cone photoreceptors in the fovea and can help to identify this area (Fig. 10).

The umbo (also called foveal pit) refers to the deepest part of the foveola – here, you will often find an increased reflectivity as the light rays hit the axons at a right angle. The umbo hyperreflectivity in an OCT scan marks the foveola and thus the point of sharpest vision (Fig. 10).



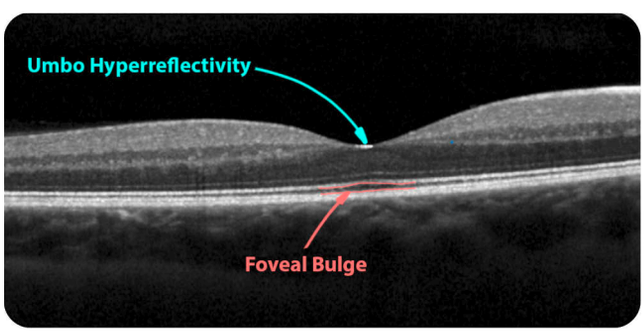
(Fig. 9) Scan location. The grid separates the macula into the superior, temporal, inferior and nasal quadrants

Laterality

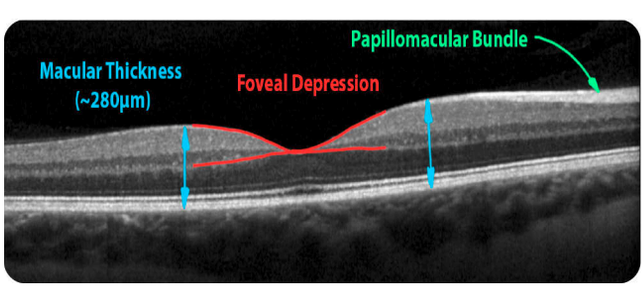
Since all nerve fibers leave the eye via the optic disc, the fibers group in the papillomacular bundle, resulting in a thickening of the RNFL nasally. This increase in thickness can be used as a landmark for laterality orientation. For example, if the RNFL is thicker on the right side in a horizontal scan, you are looking at a scan of a right eye and vice versa (Fig. 11).

Thickness

A study on 7744 eyes found that the average macular thickness (MT) is around 276µm ±13,4 µm in healthy individuals[2] (Fig. 11). Therefore, we can use the MT to estimate, for example, the choroidal thickness or the extent of retinal atrophy.



(Fig. 10) The foveal bulge marks the area of the fovea. The umbo hyperreflectivity marks the foveola



(Fig. 11) The average macular thickness is around 280 µm amongst healthy individuals. By following the retinal nerve fiber layer and outer plexiform layer (both marked red) you will find the foveal depression. In this scan the papillomacular (PM) bundle is on the right side of the scan – meaning we are looking at a scan of a right eye.

Check out the interactive version (**Fundus Image *interactive***).

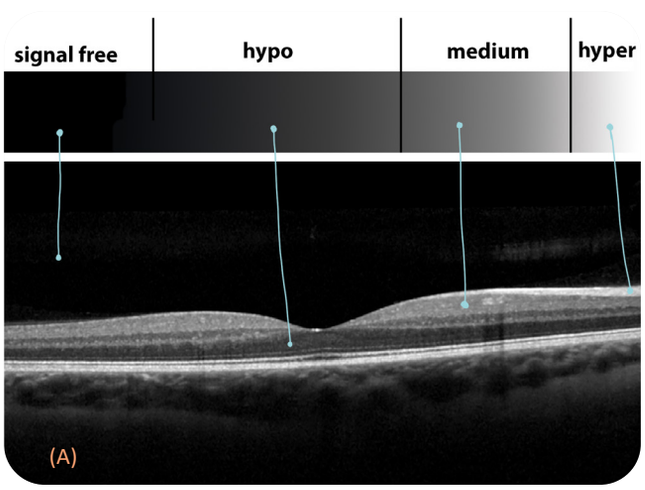
2.4.1 Landmarks

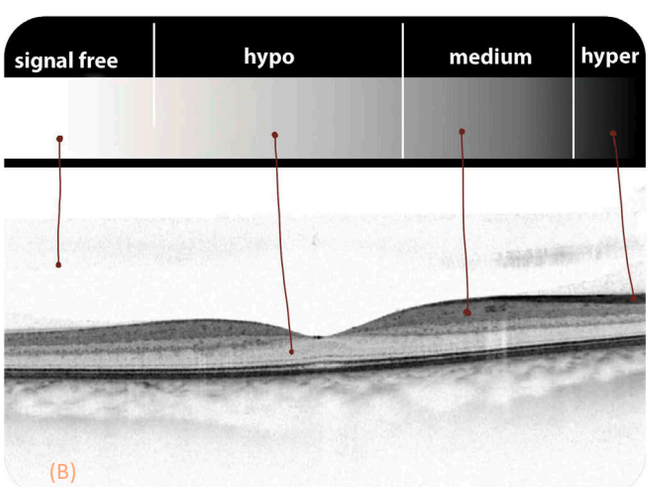
Reflectivity

Since the greyscale image, captured with an OCT, represents the reflective behavior of the individual retinal layers, the structures are described as hypo-, medium, or hyperreflective.

When setting up the OCT device, there are two possible representations one could choose, being either the “white-on-black” (Fig. 12A) or “black-on-white” (Fig. 12B) representation. We decided on the white-on-black representation for this book, to which we refer in this book.

Generally, the ONL and INL appear hyporeflective, the OPL and GCL appear medium reflective, and the RPE and RNFL are hyperreflective. Signal-free areas represent fluid or highly transparent substances (such as the vitreous) which are therefore non-reflective (black). When assessing alterations of an OCT scan, one can compare its reflectivity to these layers.





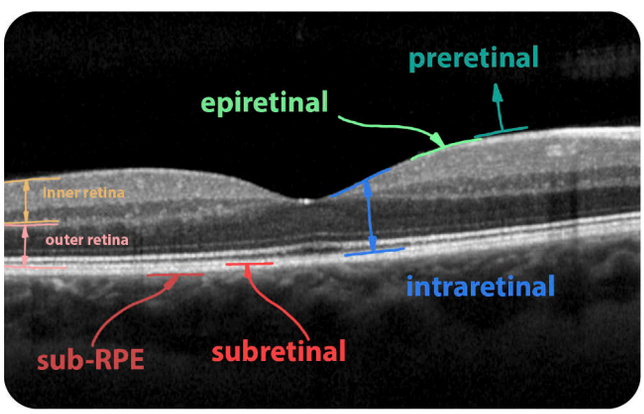
(Fig. 12) Reflective behavior of the retinal layers. A: white-on-black, B: black-on-white

Retinal Areas (Fig. 14)

The sub-RPE area includes every layer/structure below the RPE, including the choroid. It is followed by the subretinal area, which lies between the IZ/PR-OS and the RPE.

The intraretinal area is divided into the outer and inner retina. The outer retina includes the PRs reaching from the IZ, where the PRs connect to the RPE, up to the OPL, where the signals are forwarded from the PRs to the bipolar and horizontal cells. The OPL is sometimes referred to as the middle limiting membrane (MLM) as it borders the inner and outer retina; cystic fluid formations usually do not break the MLM but form on each side of it. The inner retina consists of the INL, IPL, GCL, and RNFL.

The transition between epiretina and preretina is seamless, which is why these two regions are usually grouped.



(Fig. 13) Retinal areas

2.5 Structured Assessment

2.5.1 Introduction

After completing the assessment of the IR image and the scan quality and defining the location of the scan, you can now proceed to the evaluation of the cross-sectional scan.

Especially if you are a beginner, OCT assessment and interpretation can be overwhelming at first, as there are potentially countless variations. Therefore, we created the assessment guide (Fig. 14) to support you in your learning phase. You can use it as you would use a cooking recipe – starting at the RPE and analyzing every layer and its potential alterations until you reach the vitreous.

The guide certainly will not cover every aspect of every disease, but it focuses on the most common retinal alterations. In order to better differentiate the relative importance of various alterations, the most important ones, especially those that influence therapeutic decision-making, are marked in bold.

In the beginning, you should not get overwhelmed with details like the smallest pigment migrations within the ONL in AMD patients or the number and size of hyperreflective spots (HRS) in a person with diabetes, as they will not influence your therapeutic decision-making in everyday clinical practice. However, over time, they could help to better understand the individual processes and develop a better sensitivity and understanding of the development and evolution of retinal diseases and thus refine decision-making in selected cases.

In the following chapter, we will review every aspect of the guide and provide example images for every alteration, which can then be practiced in the exercise part.

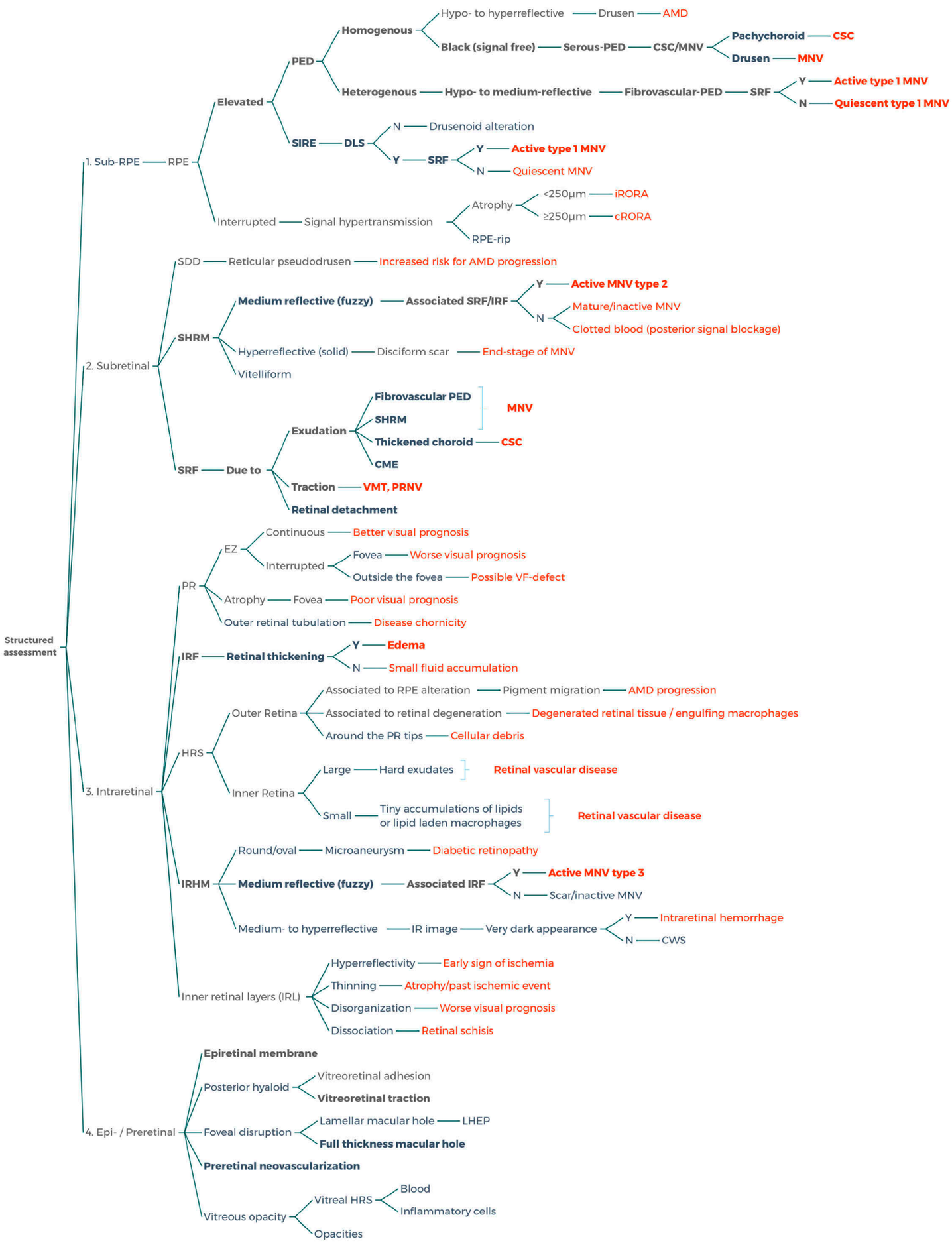
Although the application heavily relies on the underlying condition, the most common applications are the detection and monitoring of:

- Macular neovascularization (MNV) and MNV-suspect lesions
- Fluid accumulations
- Macular edema and retinal exudation
- Vitreomacular interface disorders
- Vitreous cells in uveitis

First Steps

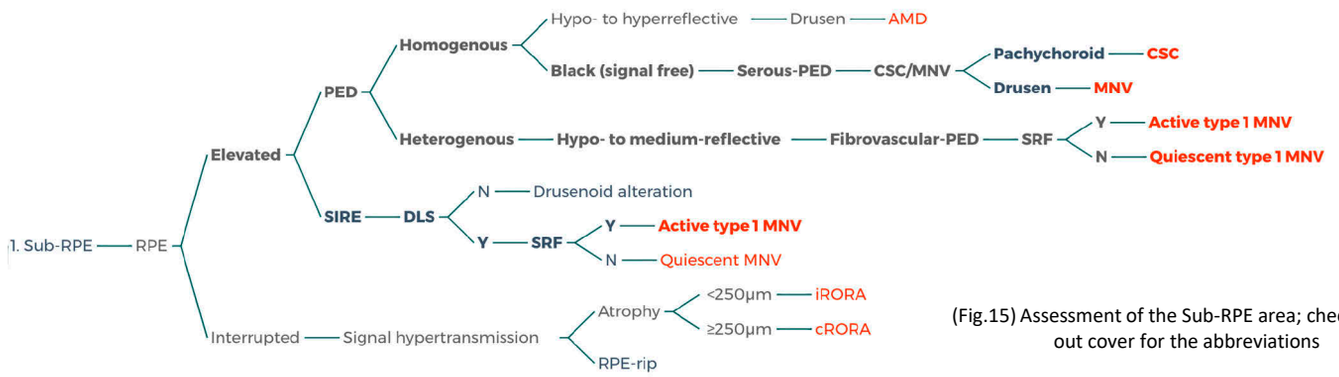
The first step in the OCT assessment is identifying the RPE layer. Starting from there, analyze the sub-RPE area first. Then continue with the subretinal, intraretinal, epi- and preretinal areas.

2.5 Structured Assessment



(Fig. 14) Assessment guide

2.5.2 Sub-RPE Area



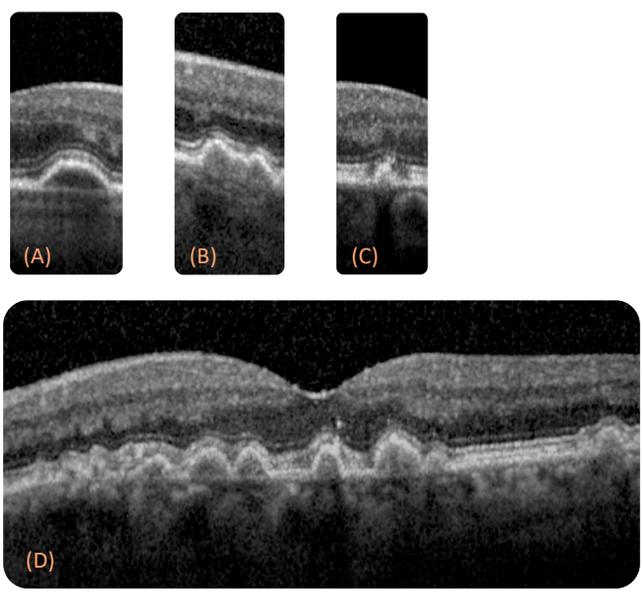
(Fig.15) Assessment of the Sub-RPE area; check our flip out cover for the abbreviations

Pigment Epithelial Detachment (PED)

A PED results from an unwanted pathologic process in either one or a combination of the following structures: the RPE, Bruch's membrane, and choriocapillaris/choroid.

Drusenoid PED/ Drusen

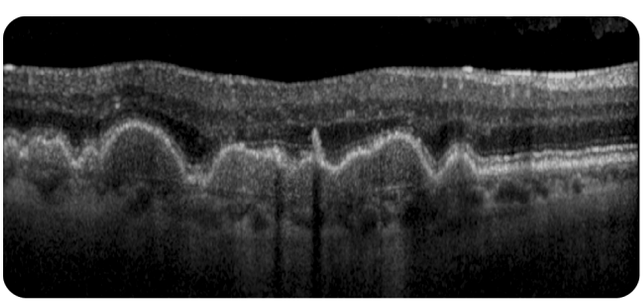
With age, the RPE loses its capacity to phagocytize and metabolize the shed photoreceptor outer segments and other cellular components. This reduced function leads to the accumulation of lipoproteins and other cellular debris between the RPE and the Bruch's membrane, resulting in the so-called drusen – a hallmark of age-related macular degeneration (AMD)[3]. Drusen usually have a homogenous, hypo- to hyperreflective appearance on OCT (Fig. 16A-C). They can vary in size and have either distinct borders or they can be confluent (Fig. 16B vs. D). There are also different types of drusen[4,5], which will be discussed in the dedicated chapter ("Drusen"). Once the size of a druse increases drastically, or multiple drusen merge and reach a size of 433 µm, it is called a drusenoid PED[3] (Fig. 17).



(Fig. 16) (A) single hyporeflective druse, (B) medium reflective confluent drusen (C) single hyperreflective druse (D) Patient with AMD with multiple drusen.

Fibrovascular PED (F-PED)

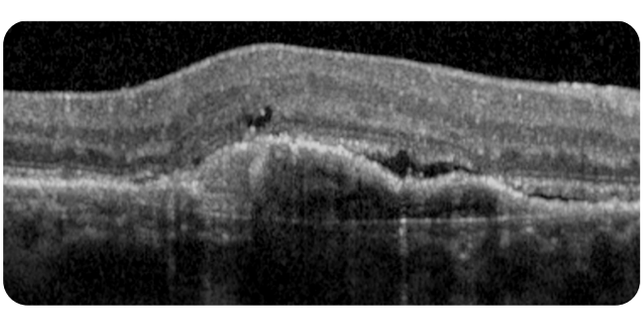
The Bruch's membrane is the last membrane of collagenous tissue separating the RPE from the choriocapillaris of the choroid[6]. Degeneration and defects of the Bruch's membrane are associated with the formation of MNV[7]. Underlying conditions could be hypoxia, trauma, inflammation, degeneration, a tumor, or idiopathic, to name a few. The newly formed vessels proliferate between the Bruch's membrane and the RPE, resulting in a fibrovascular PED. These PEDs have a heterogeneous, hypo- to medium-reflective appearance on OCT[4,5] (Fig. 18). The juvenile vessels also tend to leak or bleed; thus, a fibrovascular PED is often accompanied by subretinal fluid (SRF), a sign of active exudation.



(Fig. 17) Drusenoid PED

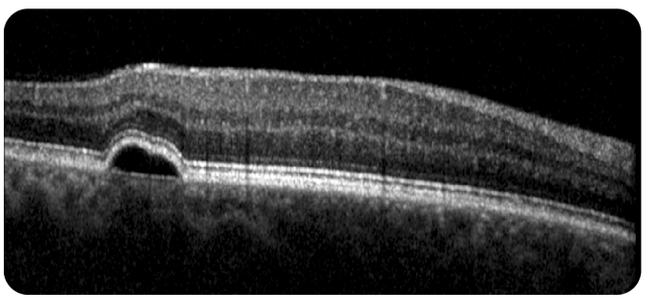
Serous PED (S-PED)

Serous PEDs (Fig. 19) appear as homogenous, signal free abrupt elevations of the RPE. The most common underlying conditions are central serous chorioretinopathy (CSC) or AMD. The serous PED in AMD is often associated with neovascularization; however, it only makes ~1% of cases of neovascular AMD (nAMD)[8]. When assessing serous PEDs, an increased choroidal thickness is an important marker for CSC, while drusen are present in AMD[4].

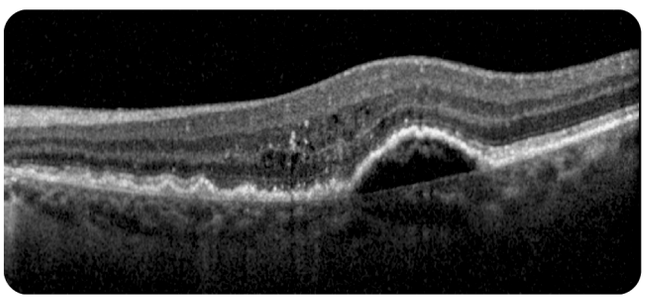


(Fig. 18) Heterogenous hypo- to medium reflective, fibrovascular PED

2.5.2 Sub-RPE Area



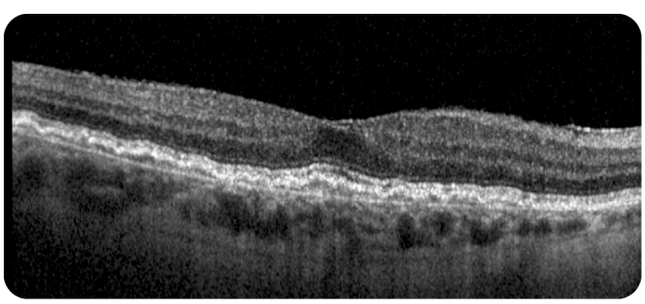
(Fig.19) Serous PED



(Fig. 20) Serous PED associated with nAMD

Shallow Irregular RPE Elevation (SIRE)

When reviewing RPE alterations, you will sometimes encounter shallow, irregular RPE elevation (SIRE)[10] where the Bruch's membrane and RPE are clearly visualized as two separate lines (double-layer sign, DLS) (Fig. 21). These lesions might present with or without signs of exudation. A study found that patients with a pachychoroid spectrum disease (choroid >270 µm in that study) and a SIRE had a type 1 MNV in 95% of the cases[9]. Patients with AMD that display a SIRE on OCT are at higher risk of having a quiescent MNV[10].



(Fig.21) Shallow irregular RPE elevation with a clearly visible DLS.

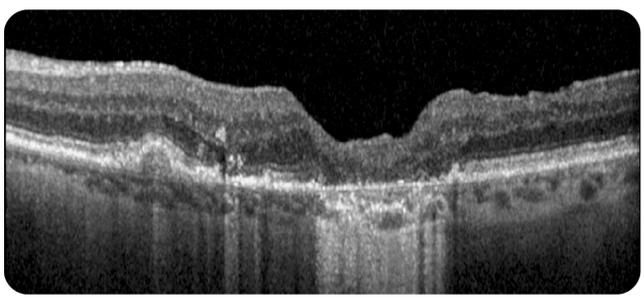
RPE Atrophy

RPE atrophy is mostly found in advanced stages of AMD (geographic atrophy (GA)) with progressive and irreversible photoreceptor, RPE, and choriocapillaris loss[14]. In 2020, a consensus on GA grading was reached, introducing two new terms: iRORA (incomplete RPE and outer retinal atrophy) and cRORA (complete RPE and outer retinal atrophy) [15,16].

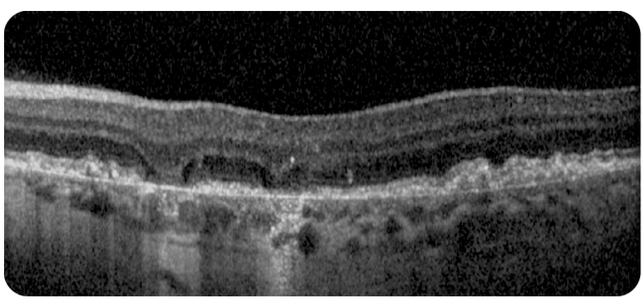
They are defined as:

1. an area of signal hypertransmission into the choroid that is associated with
2. RPE attenuation or disruption and
3. evidence of photoreceptor atrophy

While the term cRORA (Fig. 22) is used for lesion with a width of ≥250 µm, the term iRORA (Fig. 23) is used for lesions <250 µm.



(Fig. 22) cRORA



(Fig. 23) Two separate iRORA lesions

Drusen – Summary[3]

For a detailed assessment, it is essential to comprehend the different drusen subtypes, different classifications, and their risk for progression to vision-threatening stages. Therefore, this book provides an overview and the basics for the classification of drusen.

Generally, drusen can be described as hard or soft drusen based on their hard-edged or soft-edged appearance on fundoscopy.
The term "hard drusen" is generally applied to drusen smaller than 63 µm (small drusen), and the term soft drusen is applied to lesions with a size between 63 µm and 1000 µm (large drusen).

For a purely size-oriented classification, intermediate drusen with the size of 63–125 µm were introduced in addition to the small/hard (<63 µm) and large/soft (125–1000 µm) drusen.

As drusen are a hallmark of AMD, a classification based on disease severity was introduced:

- Small lesions <63 µm were considered and classified as a normal aging process.
- Patients with medium-sized drusen without pigmentary abnormalities were classified as early AMD.
- Large drusen without pigmentary changes, or medium drusen with pigmentary abnormalities, were classified as intermediate AMD.
- Choroidal neovascularization or RPE atrophy was classified as late AMD.

These classifications neglect two important subtypes of drusen, the cuticular drusen, and the subretinal drusenoid deposits.

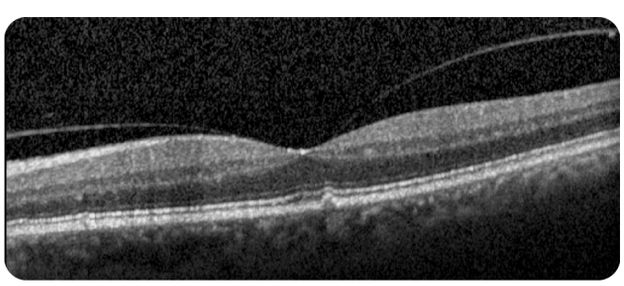
There are four specific characteristics of drusen that can be described on an OCT scan: shape, size, reflectivity, and internal consistency.

Hard/Small Drusen

Hard/small drusen appear as small, homogenous, medium- to hyperreflective elevations of the RPE; together with the formation of basal laminar deposits, they are generally seen as a normal aging process with minimal risk of progression to advanced stages of AMD (Fig. 24).

Cuticular Drusen

Although small (50–75 µm), cuticular drusen are related to a higher risk of AMD progression. In an OCT scan with cuticular drusen, the RPE is relatively thinned at the apex of the druse, and the lesions are densely packed, which results in the classic "sawtooth" appearance (Fig. 25).



(Fig. 24) Small hard druse

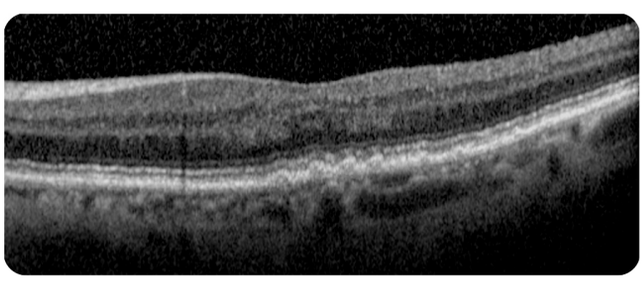
Subretinal Drusenoid Deposits

Subretinal drusenoid deposits, also known as reticular pseudodrusen, are small accumulations of drusenoid material between the RPE and the PRs. IR and OCT imaging showed to be the most reliable diagnostic tools for the detection of these lesions. It was also found that reticular pseudodrusen have a higher risk for progression to neovascular AMD than other types of drusen (Fig. 26).

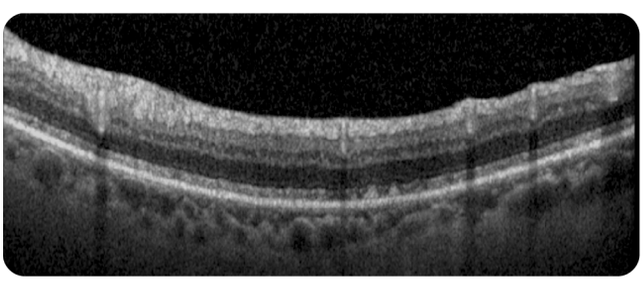
Soft Drusen

Soft drusen are homogenous, medium- to hyperreflective, dome-shaped RPE elevations of varying sizes (Fig. 27). The larger the drusen, the higher is the risk for progression to advanced stages of AMD. In addition, the presence of pigmentary abnormalities and bilaterality of the alterations increase the risk even more.

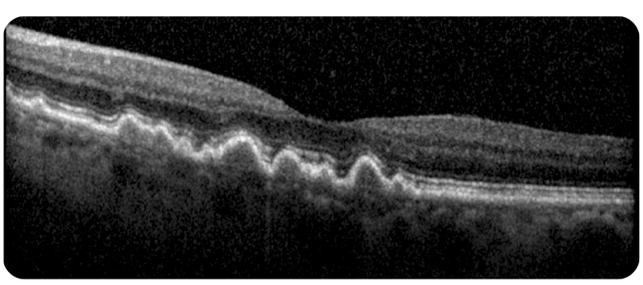
An analysis of the AREDS data provided a five-year rate of developing advanced AMD, depending on the drusen size, the presence of pigmentary abnormalities, and bilaterality of lesions. While patients with small drusen in only one eye, without pigmentary abnormalities, had the lowest risk (0.4%) of disease progression, patients with large drusen in both eyes, paired with pigmentary abnormalities, presented a risk of progression as high as 47.3%.



(Fig. 25) Cuticular drusen



(Fig. 26) Subretinal drusenoid deposits



(Fig. 27) Large soft drusen

2.5.2 Sub-RPE Area

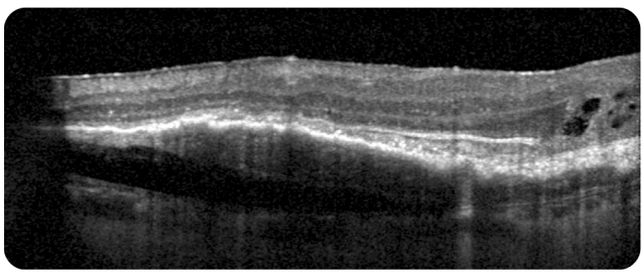
Choroid

The subfoveal choroidal thickness amongst 50-year-old healthy individuals was approximately 287 µm, measured with SD-OCT[6]. The choroidal thickness may change for example due to disease, health conditions, or as part of the normal aging process[6]. In addition, thick[11] or thin choroids are associated with specific retinal diseases or conditions, such as CSC or polypoidal choroidal vasculopathy (PCV) in the pachychoroid spectrum or an increased risk for the development of GA[12] in AMD patients in the leptochoroid spectrum.

Since a thickened choroid alone has no disease value, it should be evaluated in conjunction with specific retinal alterations, such as subretinal or sub-RPE fluid accumulations, where it may be decisive for the diagnosis.

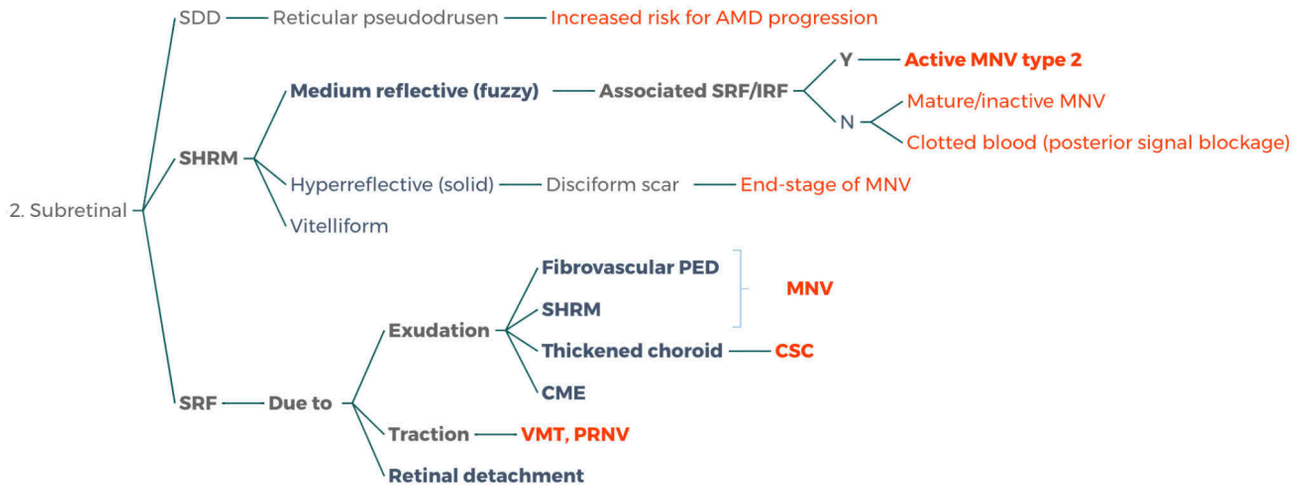
Prechoroidal Cleft (PCC)

The prechoroidal cleft is an accumulation of fluid just below the BM and above the choroid (Fig. 28). It occurs mainly in patients with nAMD who were repeatedly treated with anti-VEGF agents for MNV[13].



(Fig. 28) Prechoroidal cleft

2.5.3 Subretinal Area



(Fig. 29) Assessment of the subretinal area. VMT: Vitreomacular traction, PRNV: preretinal neovascularization, CME: cystoid macular edema, CSC: central serous chorioretinopathy

Subretinal Drusenoid Deposits

Covered in the chapter 2.5.1 Sub-RPE area – "Drusen"

Subretinal Hyperreflective Material (SHRM)

SHRM is a term that describes an accumulation of material, other than fluid, in the subretinal space. Depending on the retinal condition, there are different etiologies of SHRM with subtle differences in reflectivity. However, in most cases, they can be attributed to one of four conditions where:

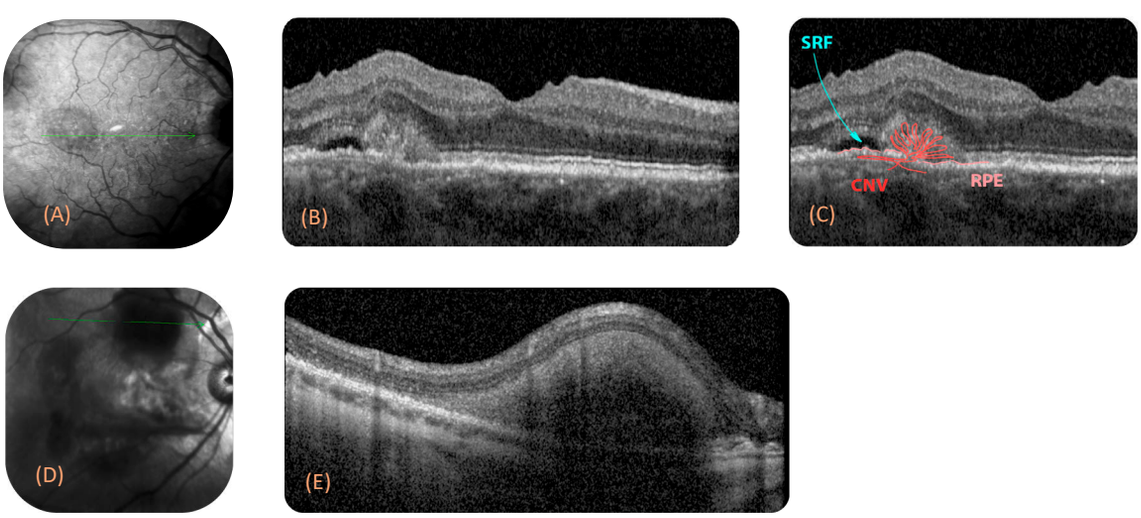
- the MNV has a fuzzy, medium reflective appearance and is often associated with fluid exudation (Fig. 30B)
- the hemorrhage appears medium reflective with posterior signal blockage (Fig. 30E)
- the fibrotic scar looks more solid and hyperreflective (Fig. 31B)
- the vitelliform lesion is a rarer, accumulation of medium to hyperreflective material in the subretinal space (Fig. 32B).

Type 2 MNV

Subretinal hyperreflective material is mostly found in eyes with type 2 MNV. It represents fibrovascular tissue, fibrin, blood, or a mix of all in the space underneath the retina or within the PR outer-segments (which were infiltrated by MNV). It has a fuzzy, hyperreflective appearance and is associated with subretinal or intraretinal fluid (IRF)[6,21] (Fig. 30 E).

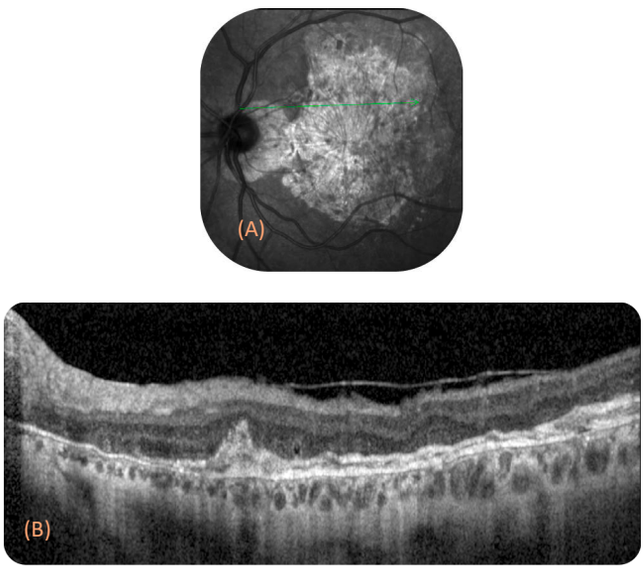
Subretinal Hemorrhage

Subretinal hemorrhage is a complication of MNV where the rupture of the juvenile vessels leads to the accumulation of blood in the subretinal space. It has a very dark appearance on the IR image and on the OCT scan it is medium to hyperreflective with adjacent signal blockage (Fig. 30C).

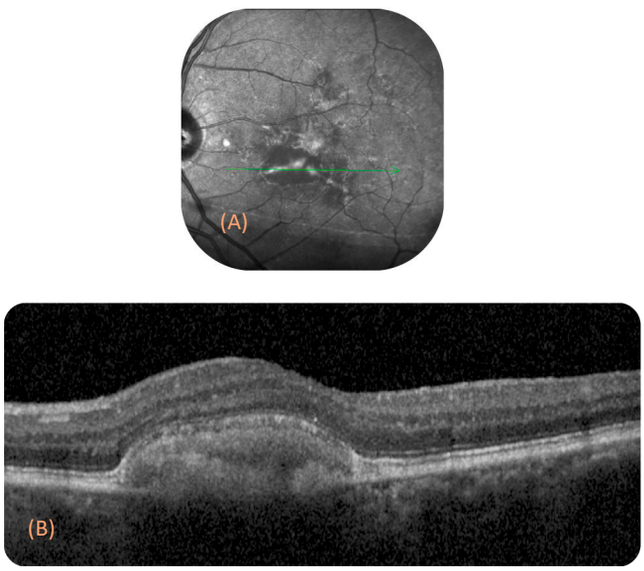


(Fig. 30) (A) IR image of a SRHM, (B) OCT scan of SHRM, (C) Illustration of the macular neovascularization, (D) IR image of a subretinal hemorrhage, (E) OCT scan of a subretinal hemorrhage

2.5.3 Subretinal Area



(Fig. 31) (A) IR image of a disciform scar, (B) OCT scan of a subretinal scar



(Fig. 32) (A) IR image of a vitelliform lesion, (B) OCT scan of a vitelliform lesion

Disciform Scar

Persistent type 2 MNV can lead to scarring due to the consolidation of fibrous material. Subretinal scars appear as an accumulation of hyperreflective material, with a more solid look (Fig. 31B) – they can be associated with SRF[6,21]. On the IR image a scar appears as an area of hyperreflective material (Fig. 31A).

Vitelliform Lesion

Vitelliform (egg-yolk colored, as viewed on color fundus photography, CFP) material consists mainly of PR debris, which could result from a faulty RPE phagocytosis process[22]. As viewed on OCT, the medium to hyperreflective material accumulates between the RPE and the retina (Fig. 32B). It often has a cloudy inhomogeneous medium to hyperreflective appearance, which can be associated with SRF and could be mistaken as a neovascularization. The underlying conditions include Best vitelliform macular dystrophy (young patients) and various pattern dystrophies such as the adult-onset foveomacular vitelliform dystrophy[23].

Subretinal Fluid (SRF)

On OCT, the subretinal fluid appears as a hyporeflective lamella of varying size underneath the retina. There are three significant ways of fluid accumulating beneath the retina: exudation from vessels, tractional forces pulling the retina away from the underlying RPE, or a tear in the retinal tissue that leads to subretinal inflow of fluid from the vitreous.

Exudation

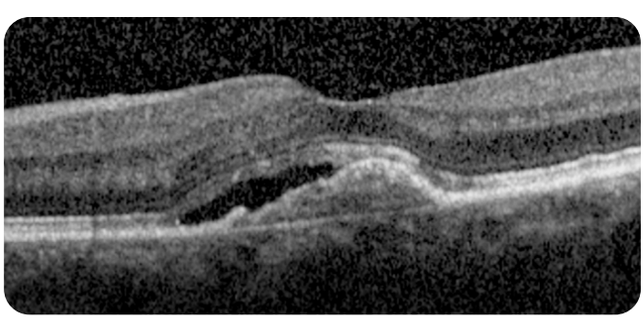
There are numerous reasons for exudation, but the basic principle of exudation is the increased permeability of vessels. Increased permeability can be caused by:

- inflammatory mediators in inflammatory disease,
- immature vessels and VEGF in neovascular diseases, or
- an altered blood flow like in CSC[17,18].

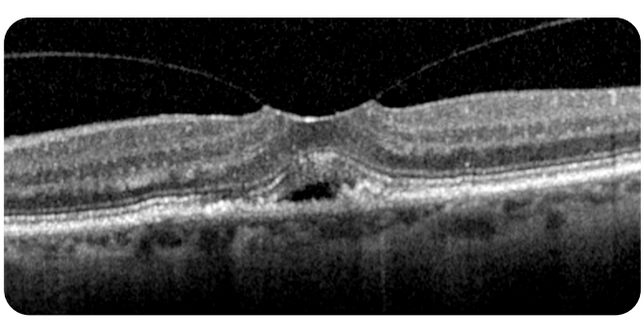
In the case of exudation, there usually is a topographic relation between the SRF and the area of exudation (at the level of the RPE), which you should look for in the OCT scan (Fig. 33).

Traction

Another way of fluid accumulating underneath the retina is by mechanical forces pulling the retina away from the RPE. One cause, for example, could be a vitreomacular traction (VMT) that pulls the retina away from the RPE (in the process of posterior vitreous detachment (PVD)), resulting in a separation of the retina from the RPE with the accumulation of SRF[19] (Fig. 34). Preretinal neovascular membranes may cause the same, leading to tractional retinal detachments.



(Fig. 33) SRF accumulation due to exudation from a fibrovascular pigment epithelial detachment (F-PED)

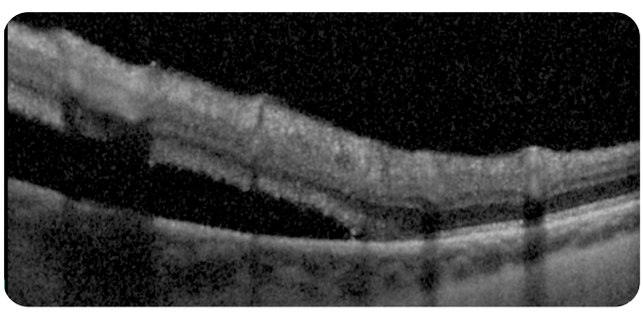


(Fig. 34) SRF accumulation due to vitreomacular traction

Retinal Tear

A tear in the retina, in most cases, occurs in the periphery around the vitreous base, where the vitreous is firmly attached to the retinal tissue. When the vitreous collapses in the process of PVD, it may cause a tear or hole in the retinal tissue, from where the fluid can leak into the subretinal space, leading to widespread accumulations of SRF (Fig. 35) and thus a rhegmatogenous retinal detachment. Other causes for retinal detachment include severe exudation or preretinal tractional neovascular membranes[18].

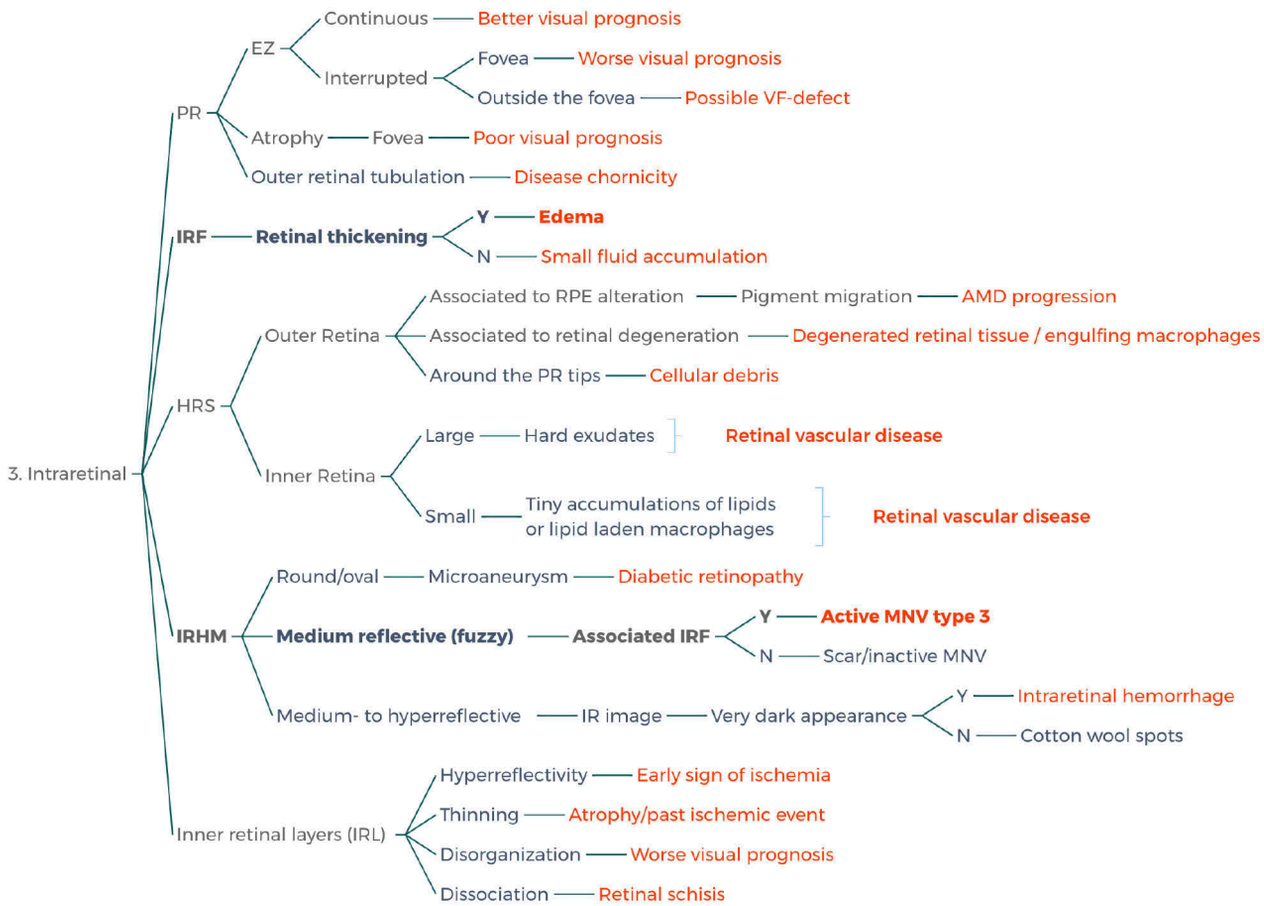
Temporary, small fluid accumulations usually have a good visual prognosis, but as duration and size increase, the malnutrition of the photoreceptors may result in degeneration of those, leading to persistent vision loss[20].



(Fig. 35) SRF accumulation due to a rhegmatogenous retinal detachment

2.5.4 Intraretinal Area

2.5.4 Intraretinal Area

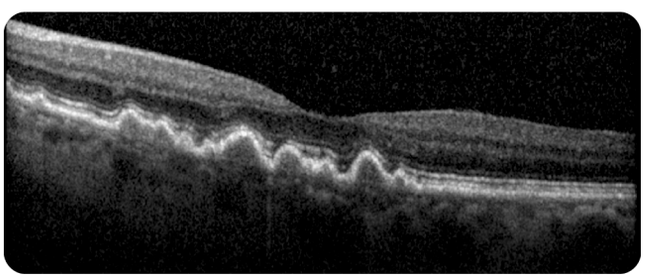


(Fig. 36) Assessment of the intraretinal area; IRF: Intraretinal Fluid, VF: Visual Field

Photoreceptors (PR)

Ellipsoid Zone (EZ)

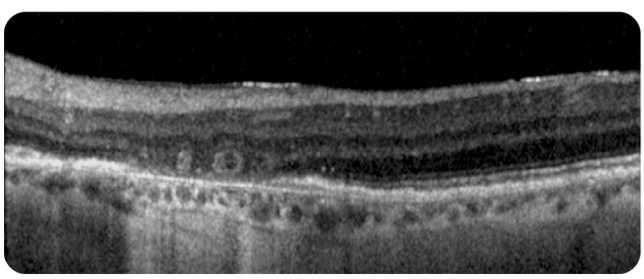
In the current understanding the EZ represents the mitochondria loaded area of the PRs (Fig. 5 Chapter 1). Studies have found that the EZ and the ELM integrity positively correlate with the VA in a wide variety of retinal conditions. Patients with a continuous EZ/ELM have better visual outcomes after treatment than those with an interrupted/fragmented EZ/ELM. That was found to be true in patients with AMD[24], retinal vein occlusion (RVO)[25], DR[26], or epiretinal membrane (ERM)[27]. When tested with microperimetry, areas with an interrupted EZ are less sensitive[28]. It was also reported that a granulated appearance of the PR/EZ has a worse visual prognosis than a smooth appearance in patients with SRF[20].



(Fig. 37) The ellipsoid zone (EZ) is interrupted multiple times.

Outer Retinal Tubulation (ORT)

Outer retinal tubulation usually occurs in advanced stages of AMD and could sometimes be misinterpreted as fluid accumulations[29]. Instead, it represents a rearrangement of the PRs, which, on OCT, is recognized by a hyporeflective lumen, with a hyperreflective ring that consists of the PRs mitochondria and the ELM[30] (Fig. 38). ORT is located within the avascular ONL and should not be misinterpreted as microaneurysms, which are alterations of the precapillary arterioles of the central retinal artery and lie within the inner retinal layers.



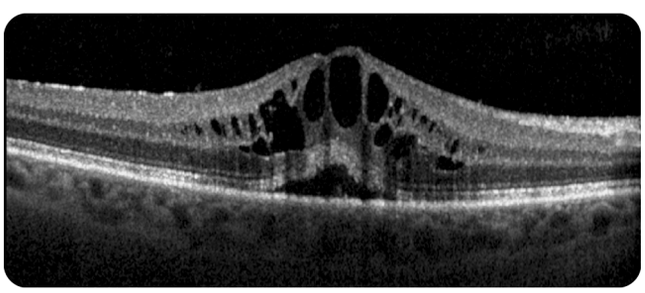
(Fig. 38) Area of outer retinal tubulation with a hyperreflective ring and a hyporeflective lumen

Cystoid Macular Edema (CME)

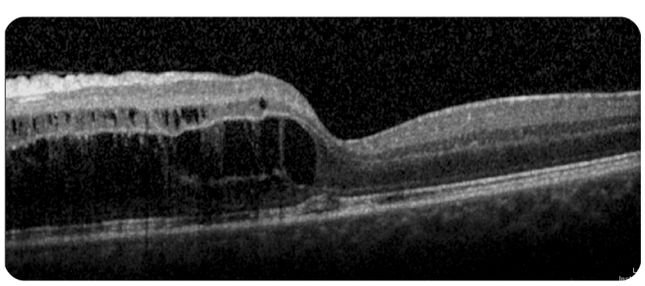
CME is the consequence of a wide variety of retinal and ocular conditions (only a few are named here). An increased retinal capillary permeability is a major cause of CME, especially in retinal vascular diseases such as DR (loss of pericytes and endothelial cells), RVO/branch retinal vein occlusion (BRVO) (altered capillary blood flow and hypoxia), or neovascular disease[31] (VEGF, juvenile leaky vessels). While in inflammatory diseases, the increased permeability is caused by inflammatory mediators (prostaglandins), the etiology of the post-operative CME (e.g., Irvine-Gass (Fig. 39)) is not fully understood[32]. Tractional forces on the retina (ERM, VMT)[33] or toxic agents can also lead to a CME[32].

A CME is easily recognized on OCT by its honeycomb-like hyporeflective cavities within the retina and an increased retinal thickness. It can be associated with SRF[34] (Fig. 39). Cystic cavities with a rather grey than black appearance most likely contain fibrin, high-weight proteins, or hyaline material[35].

CME often leads to a decrease in VA but usually, after resolving, a good best corrected visual acuity (BCVA) can be achieved. However, a prolonged course of the disease can lead to irreversible retinal tissue damage, resulting in severe vision loss[36].



(Fig. 39) Irvine-Gass cystoid macular edema



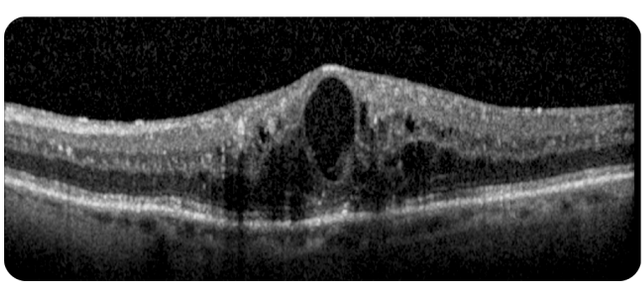
(Fig. 40) Cystoid macular edema due to branch retinal vein occlusion

Intraretinal Fluid (IRF)

IRF is the accumulation of serous fluid within the retina. As IRF spreads across the macular region, it leads to macular thickening and, thus, to a CME. A single IRF accumulation may be a sign of a local retinal degeneration.

Causes of cystoid macular edema (overview)
- Retinal vein occlusion
- Diabetic retinopathy
- Hypertensive retinopathy
- Macular neovascularization
- Uveitis
- Post-operative (e.g., Irvine-Gass syndrome)
- Post laser therapy
- Drug induced

The causes of CME can be manifold and while the OCT is the best tool to detect CME, it might be impossible to determine the underlying condition only from a single cross-sectional scan.



(Fig. 41) Cystoid macular edema due to diabetic retinopathy

2.5.4 Intraretinal Area

Hyperreflective Spots (HRS)

Many studies have dealt with the interpretation of the HRS – we grouped them into four major categories. HRS as a sign of intraretinal lipoprotein exudation, pigment migration, retinal degeneration or photoreceptor debris.

Hard Exudates

Large, intraretinal HRS are usually visible on an IR image, and represent accumulations of lipoproteins within the retina (Fig. 42). These so-called hard exudates are a sign of blood-retinal barrier breakdown and allow the assumption of a retinal vascular disease as the underlying condition or a vascular component in multifactorial disease. Smaller hyperreflective spots are invisible on an IR image – they are thought to be tiny accumulations of lipids or lipid-laden macrophages and, thus, precursors of hard exudates[37,38]. Exudates are usually located in the inner retinal layers or below the OPL as they originate from the retinal capillary plexus[6,39].

Pigment Migration (Fig. 43)

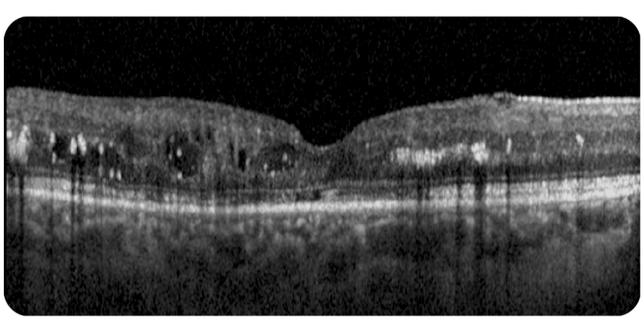
Pigment migration was found to occur in up to 50%[40] of eyes with AMD and is mainly associated with drusen[40] where usually the choriocapillaris is also compromised[41-43]; spontaneous pigment migration is rare[40]. It is thought that one (amongst others) driver of pigment migration is tissue hypoxia that causes cells to migrate towards the vascularized retina[44], triggered by inflammatory mediators and cytokines[45]. It is a sign (and risk factor) of AMD progression to nAMD or GA[46,47]. The pigmented cells mostly migrate into the ONL. Migration into the inner retinal layers is rare but possible[40].

Degenerated Retinal Tissue (Fig. 44)

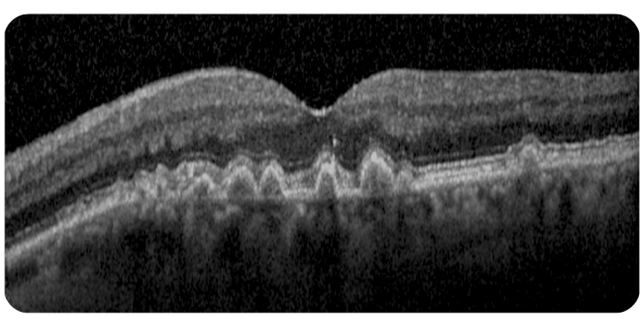
If the HRS are associated with retinal degeneration, being after prolonged CME or SRF accumulation, or in GA, the HRS can be interpreted as degenerated retinal tissue or macrophages engulfing it[38,48,49].

Photoreceptor Debris (Fig. 45)

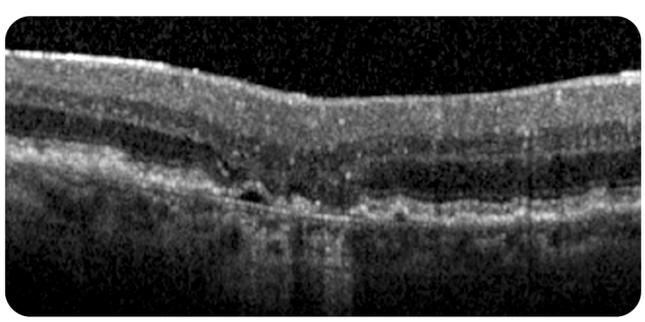
As PRs are detached from the RPE layer due to, e.g., SRF accumulation, the shed discs, and other cellular debris are no longer recycled by the RPE cells, and they accumulate around the photoreceptor tips where macrophages could engulf it. So HRS around the photoreceptor tips can usually be interpreted as photoreceptor debris or macrophages engulfing it.



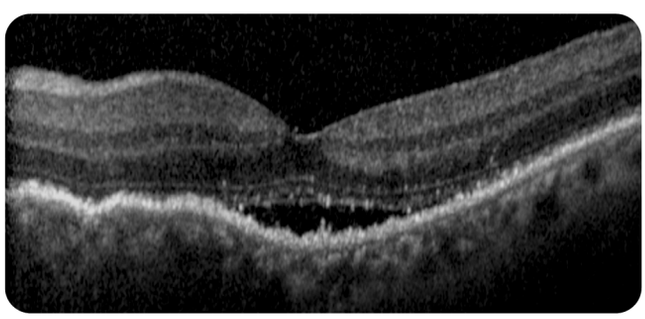
(Fig. 42) On the right side of the scan there are multiple hard exudates and on the left side one can appreciate small lipid accumulations.



(Fig. 43) The HRS associated to the druse represents migrated pigment cells.



(Fig. 44) The HRS are associated to retinal atrophy and likely represent degenerated retinal tissue or macrophages engulfing it.

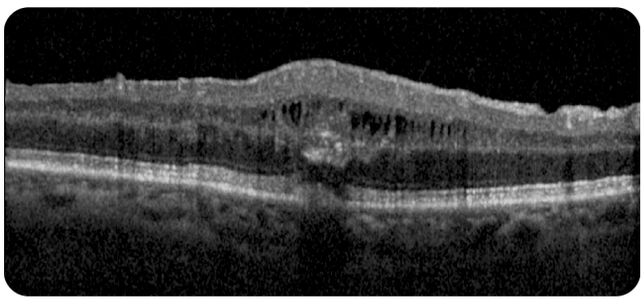


(Fig. 45) The HRS on the photoreceptor tips likely represent cellular debris.

Intraretinal Hyperreflective Material (IHRM)

Type 3 MNV

Type 3 MNV is a fibrovascular proliferation originating from the deep retinal capillary plexus (Fig. 47). The associated intraretinal fluid is a sign of active exudation[50].

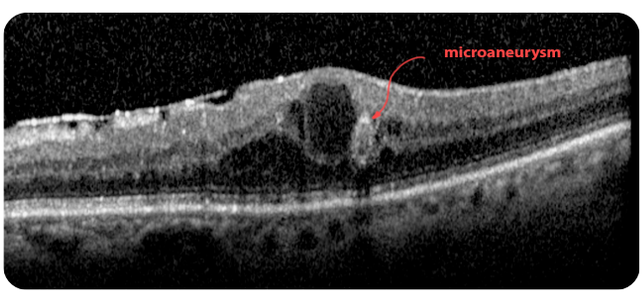


(Fig. 47) Intraretinal hyperreflective material (IRHM) representing a type 3 macular neovascularization (MNV).

Microaneurysms

Microaneurysms are a hallmark of diabetic retinopathy. Chronically elevated blood glucose levels lead to a loss of pericytes, weakening the vessel wall. Increased hydrostatic pressure may then cause an outward bulging of the vessel, forming a microaneurysm.

They have a well-defined round or oval appearance on OCT (Fig. 48). In larger lesions, one can appreciate the hyperreflective ring representing the vessel wall of the MA. The breakdown of the aneurysms may cause leakage into the retinal tissue resulting in diabetic macular edema (DME).



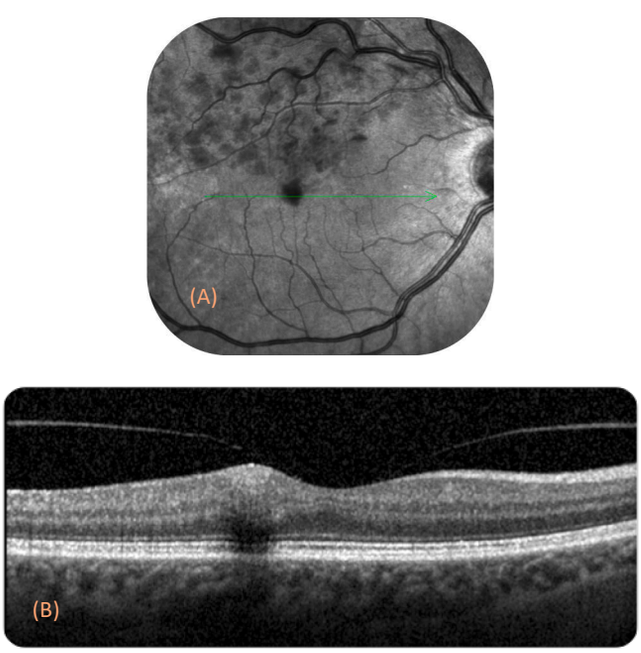
(Fig. 48) Oval microaneurysm leaking into the retina, causing a cystoid macular edema (CME).

Intraretinal Hemorrhage

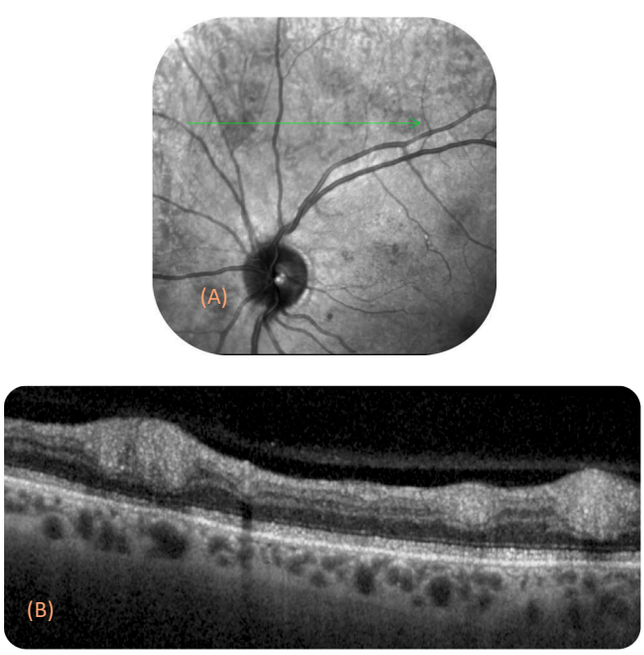
Intraretinal hemorrhage is common in retinal vascular diseases such as DR or RVO. In OCT, the hemorrhage can be recognized as an accumulation of intraretinal hyperreflective material, leading to a local thickening of the retina that is blocking the transmission of the signal[51] (Fig. 46). In the IR image they usually appear as black to hyporeflective areas.

Cotton Wool Spots (CWS)

Cotton wool spots usually occur due to a retinal perfusion impairment, with the most common causes being diabetes and hypertension[52]. The ischemia leads to an interruption of the axonal transport and results in an intracellular edema[52,53]. On OCT, they appear as a round thickening of the RNFL that is causing slight to no posterior signal blockage (Fig. 49). The CWS are hardly visible hyporeflective areas in the IR image.



(Fig. 46) (A) IR scan and (B) OCT scan of an intraretinal hemorrhage

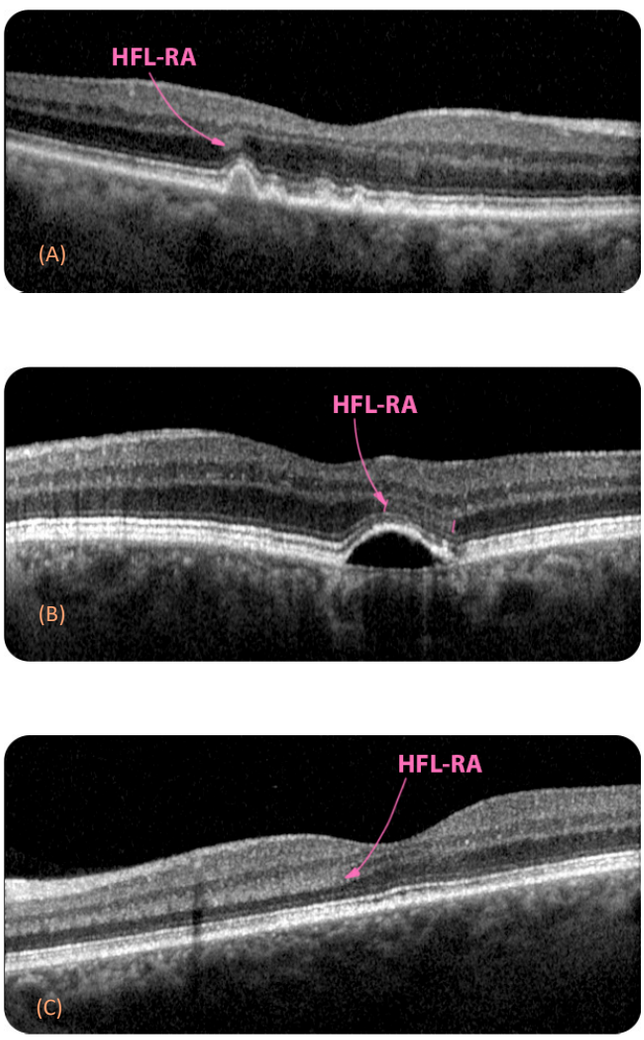


(Fig. 49) (A) IR image and (B) OCT scan of cotton wool spots

2.5.4 Intraretinal Area

Henle Fiber Layer Reflex Artifact (HFL-RA)

A HFL-RA appears as a medium reflective thickening of the OPL and might be mistaken as a pathologic retinal alteration. However, it occurs when the angle of incidence of the light beam from the OCT hits the HFL at a certain angle, resulting in an increased reflectivity (Fig. 50A–C). It is possible to simulate an HFL-RA by pivoting the OCT camera from left to right, causing the depicted retina to pan in the horizontal plane, resulting in a "thickened" OPL (Fig. 50C).



(Fig. 50) HFL-RA caused by: (A) a druse, (B) a serous PED, (C) a horizontally panned scan

Inner Retinal Layers (IRL)

Hyperreflectivity of Inner Retinal Layers

In acute phases of ischemia, cellular functions are impaired, leading to intracellular edema and manifest as hyperreflective swelling of the retinal layers on OCT. While a central retinal artery occlusion (CRAO) results in a diffuse swelling of all inner retinal layers (Fig. 52), the infarction of precapillary retinal arterioles (superficial or deep capillary plexus) may result in local alterations of the affected area (Fig. 53 vs. 54). A variety of conditions such as diabetes, hypertension, sickle cell disease, HIV, or systemic lupus can lead to vascular insults by damaging the endothelium, embolization, or secondary to inflammation[54]. While vascular insults of the superficial capillary plexus usually result in CWS[54] (Fig. 53), infarctions of the deep capillary plexus result in hyperreflectivity and slight swelling of the middle retinal layers (Fig. 54). This condition is called paracentral acute middle maculopathy (PAMM)[55] if it is a secondary event to an underlying condition mentioned above.

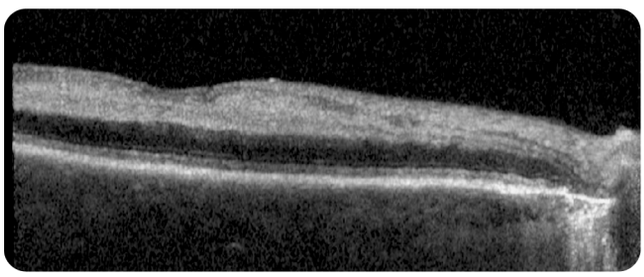
Furthermore, a study found that ischemic retinas often present a prominent middle limiting membrane (p-MLM) (Fig. 54), which they refer to as a reliable indicator for acute ischemic damage[56].

Thinning of Inner Retinal Layers

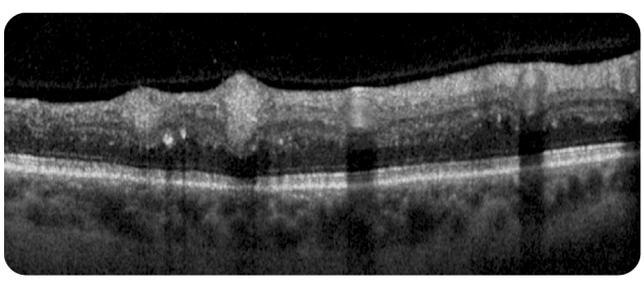
The evolution of retinal ischemic events (viewed on OCT) usually starts with the above-mentioned hyperreflectivity of retinal layers and ends in a thinning/atrophy in chronic stages. Thus, a thinning of retinal layers (OPL–RNFL) is suspect to a past ischemic event (Fig. 55).

Disorganization of Retinal Inner Layers (DRIL)

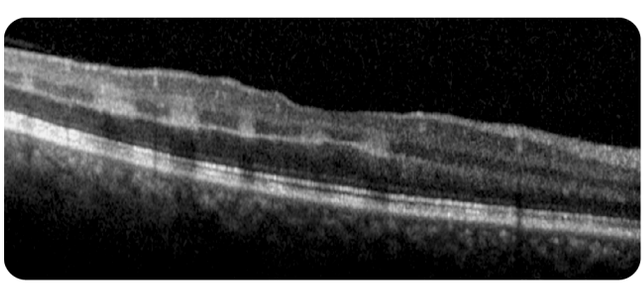
Patients with a disorganization of the retinal inner layers (DRIL) were found to have worse visual outcomes after treatment and/or resolution e.g., of center-involved DME[57,58] (Fig. 51), uveitic CME[59], CME due to RVO[60] or a DRIL due to an ERM[61] (Fig. 56). While the DRIL in vascular diseases is subtle and presents as a loss of contour of the individual layers, the DRIL caused by ERMs presents more clearly and is easier to recognize by the additional hyperreflective layer on the retina.



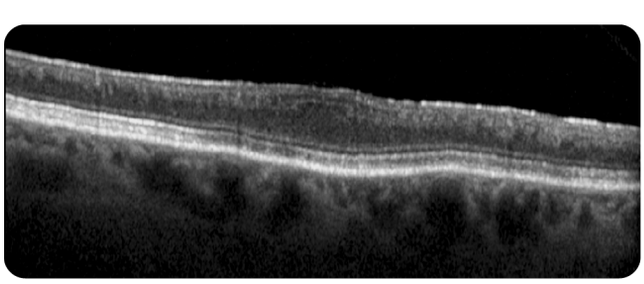
(Fig. 52) Diffuse swelling of the inner retinal layers after a central retinal artery occlusion (CRAO)



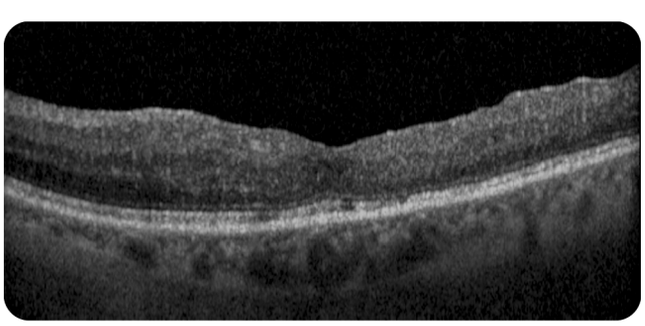
(Fig. 53) Cotton wool spots (CWS) resulting from insults of the superficial capillary plexus



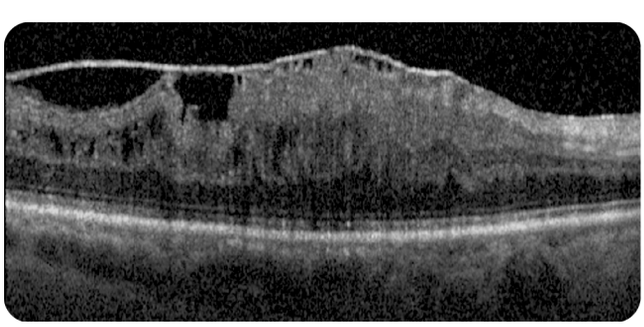
(Fig. 54) Paracentral acute middle maculopathy (PAMM) and prominent middle limiting membrane (p-MLM) resulting from insults within the deep capillary plexus



(Fig. 55) Thinning of the inner retinal layers after an ischemic event



(Fig. 51) Disorganization of the retinal inner layers (DRIL) after resolution of a diabetic macular edema (DME)



(Fig. 56) Disorganization of the retinal inner layers (DRIL) caused by an epiretinal membrane (ERM)

2.5.4 Intraretinal Area

Macular Neovascularization – Summary

MNV is a complication of a multitude of retinal/ocular diseases. Circulatory failures, obstructions[62], or stasis may result in tissue hypoxia and the release of growth factors such as VEGF to revascularize the metabolically deprived tissue[63]. Furthermore, it was found that the Bruch's membranes' degeneration is strongly associated with MNV[7]. Thus, any diseases/conditions that could compromise the Bruch's membrane are in danger of MNV development.

Anti-VEGF therapy has shown to be very effective in all types of MNV, showing promising results in VA gain when administered in a timely manner. Early identification of OCT-based biomarkers such as PEDs, SHRM, SRF, and IRF warrants immediate treatment, leading to a better prognosis.

Their topographic location differentiates three significant types of MNV: types 1–3. Active MNVs are always associated with fluid accumulation due to serous fluid exudation from the juvenile leaky vessels and VEGF[44]. It is difficult to estimate exact incidences of the different subtypes of MNV as different studies present varying results. However, the type 1 MNV was shown to be the most common, making up 25–40% of MNV subtypes. The other subtypes show a relatively large spread of the incidences, depending on the studied population.

Type 1 MNV (Fig. 57)

Type 1 MNV, previously classified as occult choroidal neovascularization (CNV) on fluorescein angiography (FA), is a vascular proliferation underneath the RPE[64]. On OCT, it presents as a heterogeneous, hypo- to medium reflective elevation of the RPE (representing fibrovascular material); if leakage is substantial, it might present as, or be accompanied by, a serous PED[4].

Type 2 MNV (Fig. 58)

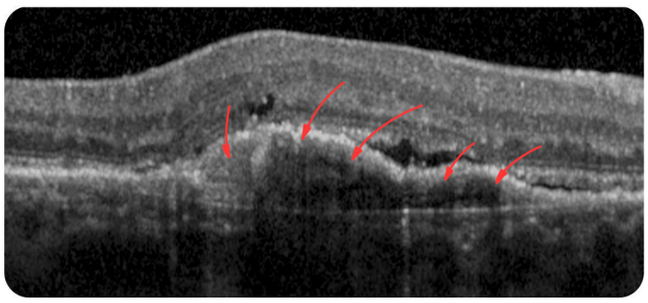
In Type 2 MNVs, the neovascular membrane infiltrates the subretinal space or retinal tissue through a tear in the RPE-Bruch's membrane complex. Historically it is also referred to as "classic" CNV due to the visualization of neovessels on FA[64]. On OCT, eyes with type 2 MNV present with SHRM and fluid accumulations, representing the fibrovascular tissue and exudation in this area[6].

Mixed Type MNV

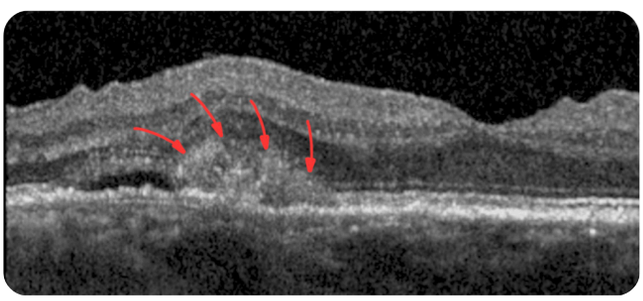
Sometimes a mixed type MNV occurs, usually from a combination of type 1 and type 2 MNV, identifiable on OCT by a fibrovascular PED with associated SHRM and SRF/IRF[64].

Type 3 MNV (Fig. 59)

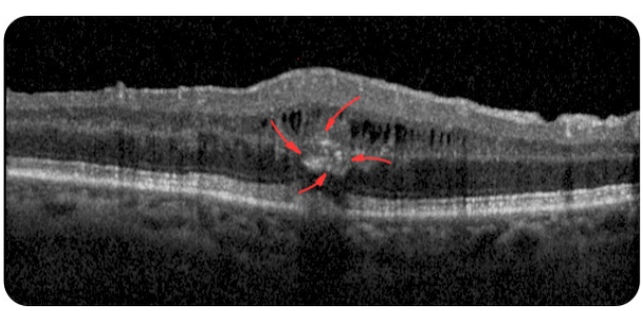
Patients with AMD often have a compromised choriocapillaris in areas with drusen or SDD, leading to a tissue undersupply with subsequent release of angiogenic factors. The excessive concentration of these factors ultimately leads to a proliferation of vessels from the deep capillary plexus towards the undersupplied areas[44]. As the type 3 MNV originates in the retinal capillary plexus, it presents on OCT as an accumulation of fuzzy-looking IHRM with associated IRF.



(Fig. 57) Type 1 MNV



(Fig. 58) Type 2 MNV



(Fig. 59) Type 3 MNV

In many countries, guidelines still recommend fluorescein angiography as the diagnostic procedure for the definite diagnosis of MNV before initiating anti-VEGF therapy. That is because FA was used as the main diagnostic tool in many pivotal trials. However, additional imaging methods have significantly improved retinal diagnostics in recent years. Multimodal imaging with OCT, OCT angiography (OCT-A), fundus autofluorescence, multicolor, or digital fundus photography may in many cases be reliable to diagnose an MNV and set a clear indication for the initialization of therapy, even without prior dye angiography. This can avoid delayed initiation of treatment, for example, in neovascular AMD, minimize examination risks, and free up resources in daily routine. In this book, the focus is only on the capabilities (and therefore also limitations) of the OCT. With that said, the experienced expert may decide based on these instruments and local guidelines which imaging methods are suitable to ensure a reliable diagnosis with a clear indication for the initiation of therapy. This book trains you to recognize OCT-specific markers of MNV to enable precise diagnostic and therapy planning.

Risk Factors For AMD Progression

In patients with nAMD, early treatment with anti-VEGF agents is essential to preserve vision and avoid irreversible retinal damage. While patient education and home vision monitoring are indispensable, symptoms might occur only when profound alterations of the macula develop. Identifying patients with a higher risk for progression is an important task of the ophthalmologist and the foundation for good patient education and follow-up planning.

While demographic and environmental, genetic, comorbidity, and molecular risk factors play a significant role in AMD progression, the following overview only includes phenotypic risk factors.

Small Drusen

Small drusen, or so-called “drupelets”, are viewed as a normal aging process with a low probability (0.4%) of developing late AMD within five years[65].

Medium (63 µm–125 µm) and Large (>125 µm) Drusen

An increase in the size of the drusen is associated with an increased risk of AMD progression, and when pigmentary abnormalities accompany the drusen, the risk increases even more.

While medium and large drusen present a risk of progression to late-stage AMD within five years of 2% and 13%, accompanying pigmentary abnormalities increase the risk to 20% and 47%, respectively[65].

Cuticular Drusen

The likelihood of cuticular drusen progressing to nAMD ranges from 9% to 13% (within five years) and to GA from 25% to 29% (within five years)[66,67].

SDD / Reticular pseudodrusen

Regardless of the disease stage based on other characteristics, SDD are of prognostic significance for the progression towards GA (15% in two years) and towards nAMD (31% in two years)[46,68-70].

Furthermore, eyes with SDD are at increased risk for developing type 3 MNV. The period between the diagnosis of MNV type 3 and fellow eye neovascularization was significantly shorter in eyes with SDD versus eyes without SDDs (14 ± 9 months vs. 21 ± 9 months)[71].

Pigment Migration (HRS)

Pigment migration represents a significant risk factor for AMD progression to nAMD and GA[12,72-74]. Over a course of 24 months 47% of eyes with HRS developed nAMD and 50% developed GA within 28 months[47,75].

Drusenoid PED

Drusenoid PEDs have an increased probability of progression to GA (19%)[76-78] and nAMD (23%)[76-78] within five years.

Choroid

One prospective study found that reduced choroidal thickness was associated with GA development[12]. However, these finding could not be replicated[70].

Quiescent MNV

Eyes with quiescent MNVs have a 15- to 18-fold higher risk of becoming exudative compared to eyes without a precursor quiescent MNV[79-81].

iRORA

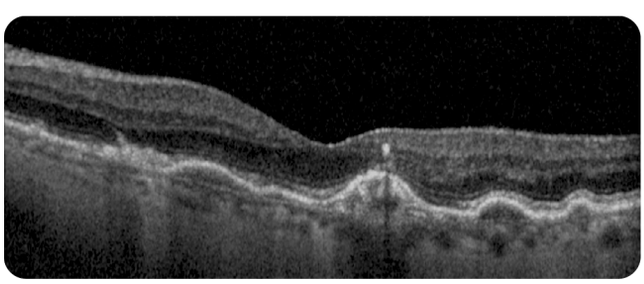
Within five years 74% of eyes with iRORA progress to cRORA[46].

ORT

An area with ORT at the border of a GA lesion has a positive effect as they slow the enlargement of the GA lesion when compared to eyes without ORT[82].

Reflective Drusen Substructures

Eyes with reflective drusen substructures (Fig. 61) are at a significantly higher risk of developing GA (not MNV) within three years.



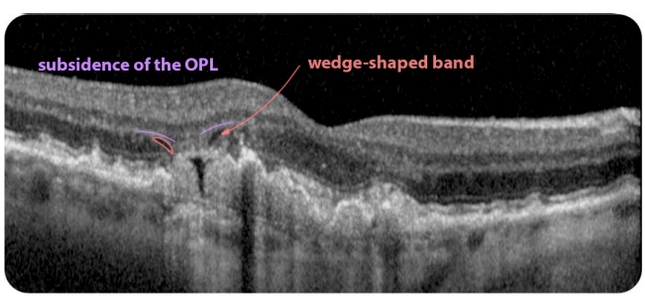
(Fig. 60) Reflective drusen substructures

Evolution of Atrophy (Fig. 61)

A research group has defined 2 changes that precede drusen-associated atrophy[88]:

- subsidence (sinking in) of the OPL and INL, and
- the appearance of a hyporeflective wedge-shaped band within the boundaries of the OPL.

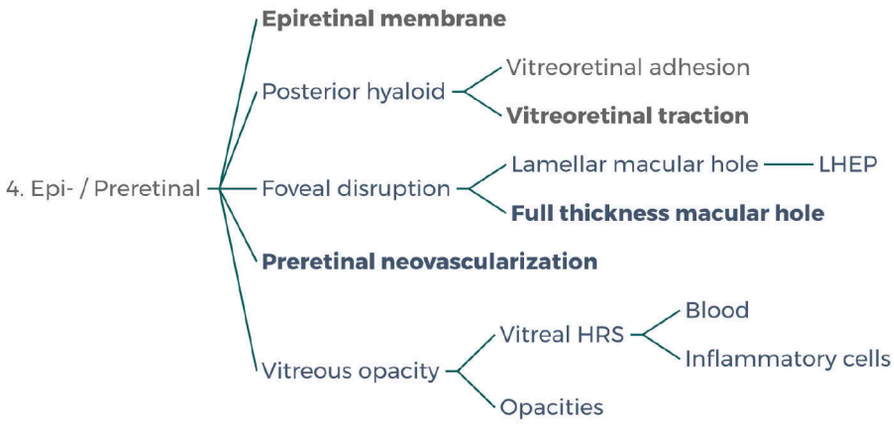
These alterations are thought to appear successive but were also found simultaneously; sometimes the atrophy directly followed the subsidence of the OPL and INL.



(Fig. 61) Evolution of geographic atrophy

2.5.5 Epi- and Preretinal Area

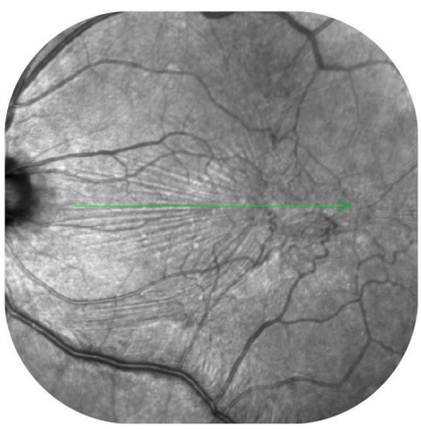
2.5.5 Epi- and Preretinal Area



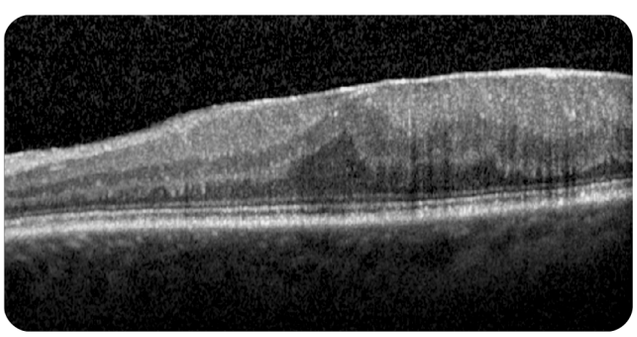
(Fig. 62) Assessment of the epi-/preretinal area; LHEP: Lamellar hole-associated epiretinal proliferation, HRS: Hyperreflective Spots

Epiretinal Membrane

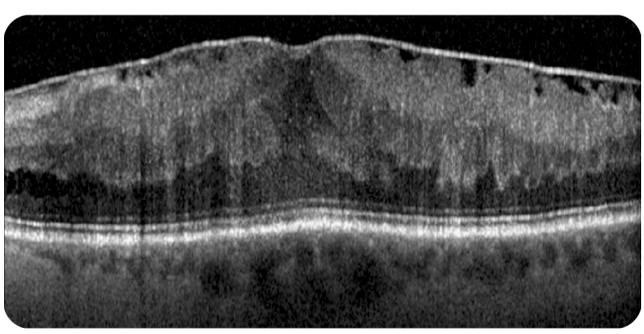
Amongst vitreoretinal interface abnormalities, epiretinal membranes (ERM) are the most common, with a prevalence of around 28% in 63–74-year-old individuals and 53% in the over 85-year-old population. On OCT, they are easily recognized as a hyperreflective band on the retinal surface or as a wrinkling of the retinal surface on the IR image. They can form after ocular surgery, trauma, inflammation, or laser therapy, to name a few; most often, they are idiopathic. Depending on their severity, they can be asymptomatic and have no impact on the retinal architecture or, in severe cases, lead to profound vision impairment. They can lead to a disorganization of the retinal layers (Fig. 66), a loss of the foveal contour (Fig. 66), as well as edema formation. Most patients only have little to no symptoms and do not need treatment; severe cases with pronounced metamorphopsia, reduced VA and/or monocular double vision may require surgery.



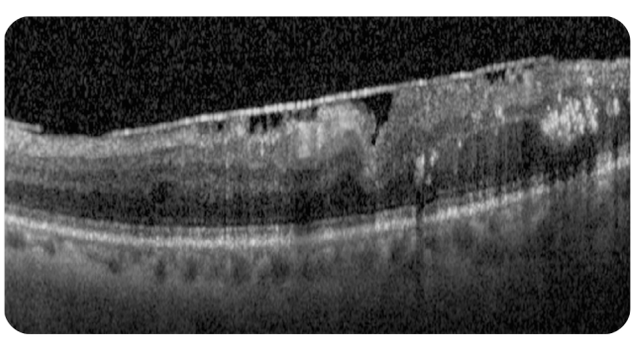
(Fig. 65) Wrinkling of the retinal surface



(Fig. 63) Epiretinal membrane causing a disorganization of the retinal layers.



(Fig. 66) Epiretinal membrane causing a loss of the foveal contour and a disorganization of the inner retinal layers.



(Fig. 64) Epiretinal membrane causing a disorganization of retinal layers.

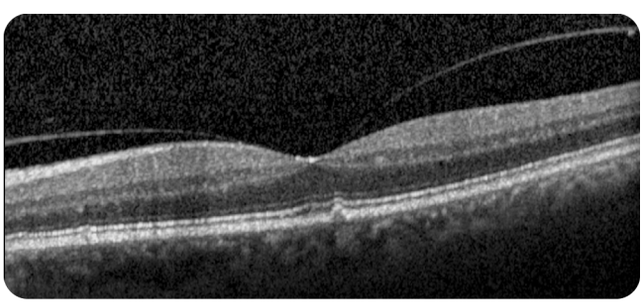
2.5.5 Epi- and Preretinal Area

Vitreomacular Adhesion/Traction (VMA/VMT)

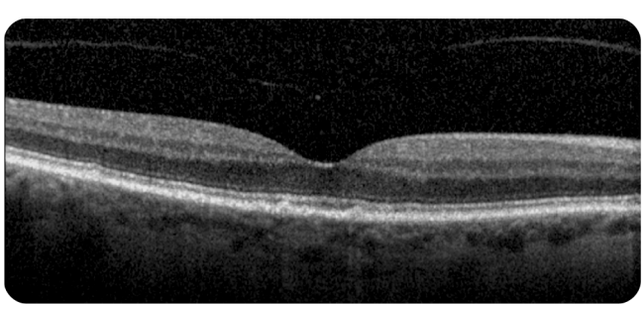
Vitreomacular adhesion (VMA) is a normal state of the human eye. What VMA defines in OCT grading is the onset of posterior vitreous detachment with visualization of the posterior hyaloid (Fig. 67). The vitreous is adherent to the retinal surface but does not cause any visual symptoms or impact the retinal architecture[19] and with time, the vitreous usually separates from the retina without any incident – resulting in a complete PVD (Fig. 68).

If the vitreoretinal adhesion is strong and the syneresis of the vitreous progresses, it can lead to VMT (Fig. 69). There are different levels of traction, causing no to severe visual symptoms or structural changes of the retina, like the accumulation of SRF (Fig. 69) or IRF.

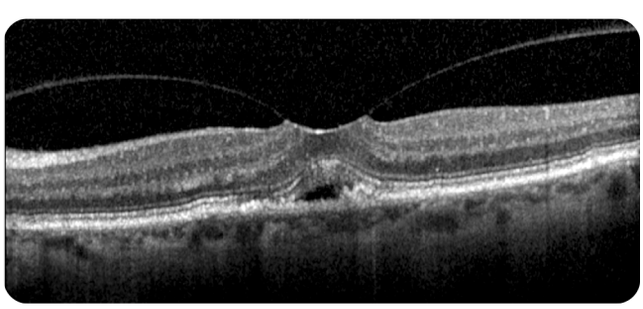
If the adhesion is strong, the traction may lead to a macular hole[19].



(Fig. 67) Vitreomacular adhesion



(Fig. 68) Posterior vitreous detachment



(Fig. 69) Vitreomacular traction

Macular Hole

Full Thickness (Fig. 70)

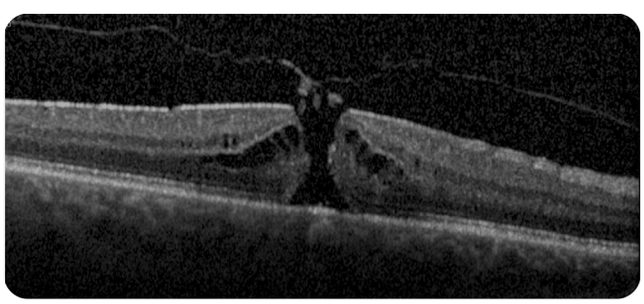
A primary full thickness macular hole (FTMH) results from the traction of the vitreous on the retina, disrupting all foveal layers from the ILM down to the RPE. It can be accompanied by intraretinal fluid.

Lamellar (Fig. 71)

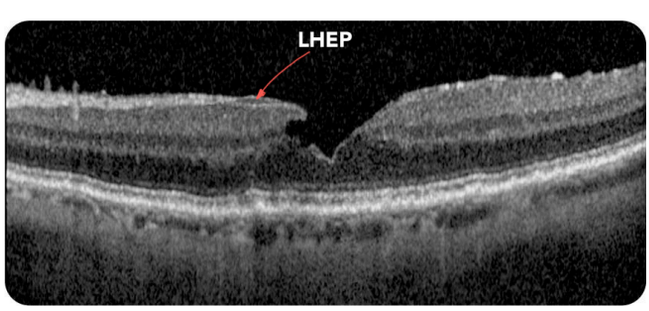
In mild cases, the traction/adhesion leads to the formation of a lamellar defect, where only parts of the retinal structure are interrupted[19]. They are associated with ERMs in 82% - 100% of cases. In addition, some cases present with lamellar hole-associated epiretinal proliferation (LHEP), which is thought to represent an extensive proliferation of Müller cells on the epiretinal surface[85]. On OCT, it presents as a thin hyporeflective lamella on the retinal surface.

Pseudo Macular Hole (Fig. 72)

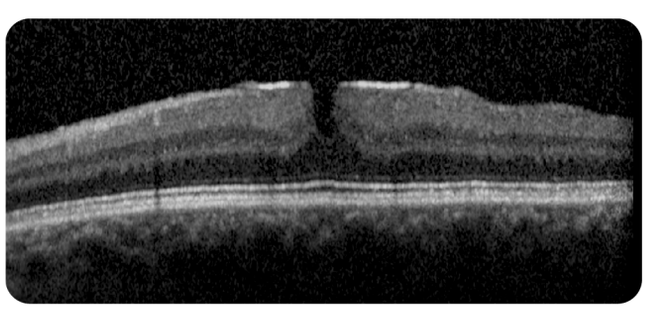
Pseudo macular holes arise from retinal deformation due to ERMs and thus are not traumatic substance defects like a lamellar macular hole (LMH) or FTMH.



(Fig. 70) Full thickness macular hole



(Fig. 71) Lamellar hole with lamellar hole-associated epiretinal proliferation

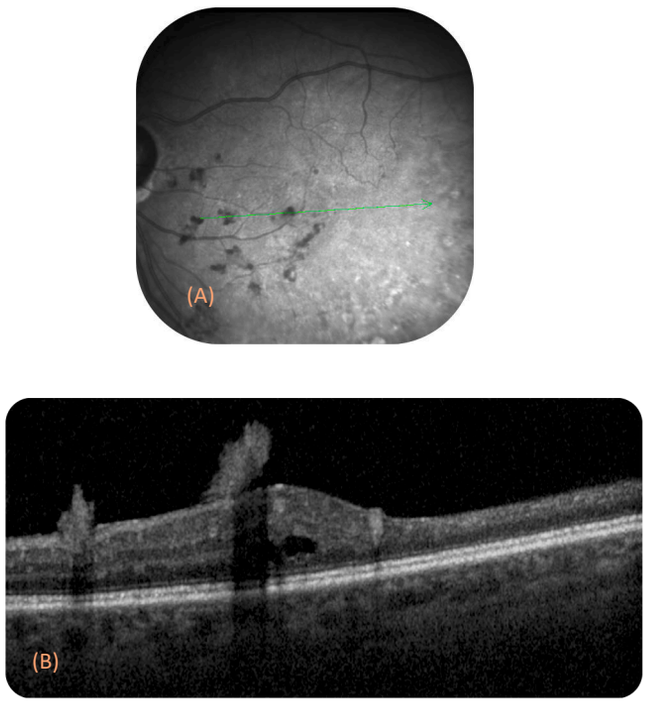


(Fig. 72) Pseudo macular hole

2.5.5 Epi- and Preretinal Area

Preretinal Neovascularization (PRNV) (Fig. 73)

Retinal ischemia in retinal vascular diseases, such as DR or ischemic RVO, can trigger neovascularization due to tissue hypoxia and subsequent secretion of angiogenic factors[86], resulting in the formation of pre-retinal neovascularization. These alterations have a dense, medium to hyperreflective appearance with adjacent signal blockage on OCT. On the IR image, they appear as hypo- to medium reflective formations.



(Fig. 73) (A) IR image and (B) OCT image of preretinal neovascularization

Summary

The OCT is an indispensable examination tool in ophthalmologic practice, as it provides microscopic, anatomically accurate cross-sections through the retina. The OCT does not replace a detailed assessment of the individual case, its ocular and systemic presentations. However, it enables us to analyze and understand, for example, funduscopic alterations, more precisely and at a microscopic level.

For accurate diagnosis and clinical decision-making, it is important to have an in-depth understanding of the pathological processes in the eye down to a cellular level and to understand the general rules by which the individual structures work and how they relate to each other.

It is a reproducible, non-invasive imaging modality that allows us to precisely observe and document the course of diseases, plan treatment regimens and monitor their effectiveness.

The retinal alterations explained in this chapter can be found in a multitude of diseases, and even if we are sometimes not able to determine the cause based on a single scan, we can use the technique proposed here to create a precise retinal assessment, which improves further therapy- and diagnostic-planning.

References

1. Heidelberg Engineering. SPECTRALIS OCT: Interpreting the image. In:2018:https://youtu.be/YUyWMWdKW4w.
2. Poh S, Tham Y-C, Chee ML, et al. Association between macular thickness profiles and visual function in healthy eyes: the Singapore Epidemiology of Eye Diseases (SEED) Study. Scientific reports. 2020;10(1):1-7.
3. Khan KN, Mahroo OA, Khan RS, et al. Differentiating drusen: Drusen and drusen-like appearances associated with ageing, age-related macular degeneration, inherited eye disease and other pathological processes. Progress in retinal and eye research. 2016;53:70-106.
4. Mrejen S. Multimodal imaging of pigment epithelial detachment: a guide to evaluation. Retina. 2013;33(9):1735-1762.
5. Pigment epithelial detachment. American Academy of Ophthalmology. https://eyewiki.aao.org/Pigment_Epithelial_Detachment. Accessed 12.12.2020, 2020.
6. BCSC: Basic and Clinical Science Course: Section 12. American Academy of Ophthalmology; 2019.
7. Campochiaro PA. Retinal and choroidal neovascularization. Journal of cellular physiology. 2000;184(3):301-310.
8. Freund KB, Sarraf D, Mieler WF, Yannuzzi LA. The Retinal Atlas E-Book. Elsevier Health Sciences; 2016.
9. Dansingani KK, Balaratnasingam C, Klufas MA, Sarraf D, Freund KB. Optical coherence tomography angiography of shallow irregular pigment epithelial detachments in pachychoroid spectrum disease. American journal of ophthalmology. 2015;160(6):1243-1254. e1242.
10. Narita C, Wu Z, Rosenfeld PJ, et al. Structural OCT signs suggestive of subclinical nonexudative macular neovascularization in eyes with large drusen. Ophthalmology. 2020;127(5):637-647.
11. Cheung CMG, Lee WK, Koizumi H, Dansingani K, Lai TY, Freund KB. Pachychoroid disease. Eye. 2019;33(1):14-33.
12. Ouyang Y, Heussen FM, Hariri A, Keane PA, Sadda SR. Optical coherence tomography–based observation of the natural history of drusenoid lesion in eyes with dry age-related macular degeneration. Ophthalmology. 2013;120(12):2656-2665.
13. Rahimy E, Freund KB, Larsen M, et al. Multilayered pigment epithelial detachment in neovascular age-related macular degeneration. Retina. 2014;34(7):1289-1295.
14. Fleckenstein M, Mitchell P, Freund KB, et al. The progression of geographic atrophy secondary to age-related macular degeneration. Ophthalmology. 2018;125(3):369-390.
15. Guymer RH, Rosenfeld PJ, Curcio CA, et al. Incomplete retinal pigment epithelial and outer retinal atrophy in age-related macular degeneration: classification of atrophy meeting report 4. Ophthalmology. 2020;127(3):394-409.
16. Sadda SR, Guymer R, Holz FG, et al. Consensus definition for atrophy associated with age-related macular degeneration on OCT: classification of atrophy report 3. Ophthalmology. 2018;125(4):537-548.
17. Iyer PG, Schwartz SG, Russell JF, Flynn HW. Central serous chorioretinopathy: multimodal imaging and management options. Case Reports in Ophthalmological Medicine. 2020;2020.
18. AAO. Retinal Detachment. https://eyewiki.aao.org/Retinal_Detachment#cite_note-6. Published 2021. Accessed 12.12.2021, 2021.
19. Duker JS, Kaiser PK, Binder S, et al. The International Vitreomacular Traction Study Group classification of vitreomacular adhesion, traction, and macular hole. Ophthalmology. 2013;120(12):2611-2619.
20. Piccolino FC, de La Longrais RR, Ravera G, Eandi CM, Ventre L, Manea M. The foveal photoreceptor layer and visual acuity loss in central serous chorioretinopathy. American journal of ophthalmology. 2005;139(1):87-99.
21. Keane PA, Patel PJ, Liakopoulos S, Heussen FM, Sadda SR, Tufail A. Evaluation of age-related macular degeneration with optical coherence tomography. Survey of ophthalmology. 2012;57(5):389-414.
22. Arnold J, Sarks J, Killingsworth M, Kettle E, Sarks S. Adult vitelliform macular degeneration: a clinicopathological study. Eye. 2003;17(6):717-726.
23. Mahdi Rostamizadeh M, Musa Abdelaziz, MD. Pattern Dystrophies. https://eyewiki.aao.org/Pattern_Dystrophies. Published 05.09.2021. Accessed 10.12.2021, 2021.
24. Mathew R, Richardson M, Sivaprasad S. Predictive value of spectral-domain optical coherence tomography features in assessment of visual prognosis in eyes with neovascular age-related macular degeneration treated with ranibizumab. American journal of ophthalmology. 2013;155(4):720-726. e721.
25. Chan EW, Eldeeb M, Sun V, et al. Disorganization of retinal inner layers and ellipsoid zone disruption predict visual outcomes in central retinal vein occlusion. Ophthalmology Retina. 2019;3(1):83-92.
26. Scarinci F, Jampol LM, Linsenmeier RA, Fawzi AA. Association of diabetic macular nonperfusion with outer retinal disruption on optical coherence tomography. JAMA ophthalmology. 2015;133(9):1036-1044.
27. Scheerlinck LM, van der Valk R, van Leeuwen R. Predictive factors for postoperative visual acuity in idiopathic epiretinal membrane: a systematic review. Acta ophthalmologica. 2015;93(3):203-212.
28. Holmes T, Larkin S, Downing M, Csaky K. En-face imaging of the ellipsoid zone in the retina from optical coherence tomography B-scans. Paper presented at: Ophthalmic Technologies XXV2015.
29. Zweifel SA, Engelbert M, Laud K, Margolis R, Spaide RF, Freund KB. Outer retinal tubulation: a novel optical coherence tomography finding. Archives of ophthalmology. 2009;127(12):1596-1602.
30. Litts KM, Wang X, Clark ME, et al. Exploring photoreceptor reflectivity via multimodal imaging of outer retinal tubulation in advanced age-related macular degeneration. Retina (Philadelphia, Pa). 2017;37(5):978.
31. Aiello LP, Northrup JM, Keyt BA, Takagi H, Iwamoto MA. Hypoxic regulation of vascular endothelial growth factor in retinal cells. Archives of ophthalmology. 1995;113(12):1538-1544.

32. Bringmann A, Reichenbach A, Wiedemann P. Pathomechanisms of cystoid macular edema. Ophthalmic research. 2004;36(5):241-249.
33. Irvine AR. Cystoid maculopathy. Survey of ophthalmology. 1976;21(1):1-17.
34. Farci R, Sellam A, Coscas F, et al. Multimodal OCT reflectivity analysis of the cystoid spaces in cystoid macular edema. BioMed research international. 2019;2019.
35. Liang MC, Vora RA, Duker JS, Reichel E. Solid-appearing retinal cysts in diabetic macular edema: a novel optical coherence tomography finding. Retinal Cases and Brief Reports. 2013;7(3):255-258.
36. Rotsos TG, Moschos MM. Cystoid macular edema. Clinical ophthalmology (Auckland, NZ). 2008;2(4):919.
37. Vujosevic S, Bini S, Midena G, Berton M, Pilotto E, Midena E. Hyperreflective intraretinal spots in diabetics without and with nonproliferative diabetic retinopathy: an in vivo study using spectral domain OCT. Journal of diabetes research. 2013;2013.
38. Bolz M, Schmidt-Erfurth U, Deak G, et al. Optical coherence tomographic hyperreflective foci: a morphologic sign of lipid extravasation in diabetic macular edema. Ophthalmology. 2009;116(5):914-920.
39. Ogino K, Murakami T, Tsujikawa A, et al. Characteristics of optical coherence tomographic hyperreflective foci in retinal vein occlusion. Retina. 2012;32(1):77-85.
40. Ho J, Witkin AJ, Liu J, et al. Documentation of intraretinal retinal pigment epithelium migration via high-speed ultrahigh-resolution optical coherence tomography. Ophthalmology. 2011;118(4):687-693.
41. Lane M, Moult EM, Novais EA, et al. Visualizing the choriocapillaris under drusen: comparing 1050-nm swept-source versus 840-nm spectral-domain optical coherence tomography angiography. Investigative ophthalmology & visual science. 2016;57(9):OCT585-OCT590.
42. Spaide RF. Choriocapillaris flow features follow a power law distribution: implications for characterization and mechanisms of disease progression. American journal of ophthalmology. 2016;170:58-67.
43. Curcio CA, Messinger JD, Sloan KR, McGwin G, Medeiros NE, Spaide RF. Subretinal drusenoid deposits in non-neovascular age-related macular degeneration: morphology, prevalence, topography, and biogenesis model. Retina (Philadelphia, Pa). 2013;33(2).
44. Spaide RF. New proposal for the pathophysiology of type 3 neovascularization as based on multimodal imaging findings. Retina. 2019;39(8):1451-1464.
45. Mitsuhiro MRKH, Eguchi S, Yamashita H. Regulation mechanisms of retinal pigment epithelial cell migration by the TGF-β superfamily. Acta ophthalmologica Scandinavica. 2003;81(6):630-638.
46. Heesterbeek TJ, Lorés-Motta L, Hoyng CB, Lechanteur YT, den Hollander AI. Risk factors for progression of age-related macular degeneration. Ophthalmic and Physiological Optics. 2020;40(2):140-170.
47. Christenbury JG, Folgar FA, O'Connell RV, et al. Progression of intermediate age-related macular degeneration with proliferation and inner retinal migration of hyperreflective foci. Ophthalmology. 2013;120(5):1038-1045.
48. Baumüller S, Issa PC, Scholl HP, Schmitz-Valckenberg S, Holz FG. Outer retinal hyperreflective spots on spectral-domain optical coherence tomography in macular telangiectasia type 2. Ophthalmology. 2010;117(11):2162-2168.
49. Uji A, Murakami T, Nishijima K, et al. Association between hyperreflective foci in the outer retina, status of photoreceptor layer, and visual acuity in diabetic macular edema. American journal of ophthalmology. 2012;153(4):710-717. e711.
50. Yannuzzi LA, Negrão S, Tomohiro I, et al. Retinal angiomatous proliferation in age–related macular degeneration. Retina. 2012;32:416-434.
51. Munk MR, Dunavoelgyi R, Baratsits M, et al. Detection and differentiation of intraretinal hemorrhage in spectral domain optical coherence tomography. Current eye research. 2015;40(10):1046-1054.
52. Schmidt D. The mystery of cotton-wool spots-a review of recent and historical descriptions. European journal of medical research. 2008;13(6):231.
53. McLEOD D, Marshall J, Kohner E, Bird AC. The role of axoplasmic transport in the pathogenesis of retinal cotton-wool spots. British Journal of Ophthalmology. 1977;61(3):177-191.
54. Yu S, Wang F, Pang CE, Yannuzzi LA, Freund KB. Multimodal imaging findings in retinal deep capillary ischemia. Retina. 2014;34(4):636-646.
55. Rahimy E, Sarraf D. Paracentral acute middle maculopathy spectral-domain optical coherence tomography feature of deep capillary ischemia. Current opinion in ophthalmology. 2014;25(3):207-212.
56. Chu YK, Hong YT, Byeon SH, Kwon OW. In vivo detection of acute ischemic damages in retinal arterial occlusion with optical coherence tomography: a “prominent middle limiting membrane sign”. Retina. 2013;33(10):2110-2117.
57. Radwan SH, Soliman AZ, Tokarev J, Zhang L, van Kuijk FJ, Koozekanani DD. Association of disorganization of retinal inner layers with vision after resolution of center-involved diabetic macular edema. JAMA ophthalmology. 2015;133(7):820-825.
58. Sun JK, Lin MM, Lammer J, et al. Disorganization of the retinal inner layers as a predictor of visual acuity in eyes with center-involved diabetic macular edema. JAMA ophthalmology. 2014;132(11):1309-1316.
59. Grewal DS, O'Sullivan ML, Kron M, Jaffe GJ. Association of disorganization of retinal inner layers with visual acuity in eyes with uveitic cystoid macular edema. American journal of ophthalmology. 2017;177:116-125.
60. Mimouni M, Segev O, Dori D, Geffen N, Flores V, Segal O. Disorganization of the retinal inner layers as a predictor of visual acuity in eyes with macular edema secondary to vein occlusion. American journal of ophthalmology. 2017;182:160-167.
61. Zur D, Iglicki M, Feldinger L, et al. Disorganization of retinal inner layers as a biomarker for idiopathic epiretinal membrane after macular surgery—the DREAM study. American journal of ophthalmology. 2018;196:129-135.
62. Linsenmeier RA, Zhang HF. Retinal oxygen: from animals to humans. Progress in retinal and eye research. 2017;58:115-151.
63. Joussen AM, Gardner TW, Kirchhof B, Ryan SJ. Retinal vascular disease. Vol 75: Springer; 2007.

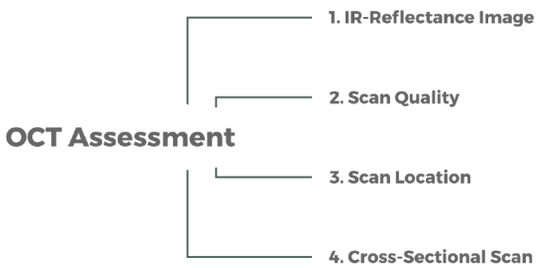
63. Joussen AM, Gardner TW, Kirchhof B, Ryan SJ. Retinal vascular disease. Vol 75: Springer; 2007.
64. Grossniklaus HE, Green WR. Choroidal neovascularization. American journal of ophthalmology. 2004;137(3):496-503.
65. Ferris III FL, Wilkinson C, Bird A, et al. Clinical classification of age-related macular degeneration. Ophthalmology. 2013;120(4):844-851.
66. Balaratnasingam C, Cherepanoff S, Dolz-Marco R, et al. Cuticular drusen: clinical phenotypes and natural history defined using multimodal imaging. Ophthalmology. 2018;125(1):100-118.
67. Sakurada Y, Parikh R, Gal-Or O, et al. Cuticular drusen: risk of geographic atrophy and macular neovascularization. Retina. 2020;40(2):257-265.
68. Joachim N, Mitchell P, Kifley A, Rochtchina E, Hong T, Wang JJ. Incidence and progression of geographic atrophy: observations from a population-based cohort. Ophthalmology. 2013;120(10):2042-2050.
69. Finger RP, Wu Z, Luu CD, et al. Reticular pseudodrusen: a risk factor for geographic atrophy in fellow eyes of individuals with unilateral choroidal neovascularization. Ophthalmology. 2014;121(6):1252-1256.
70. Sakurada Y, Sugiyama A, Kikushima W, et al. Pseudodrusen pattern and development of late age-related macular degeneration in the fellow eye of the unilateral case. Japanese journal of ophthalmology. 2019;63(5):374-381.
71. Chang YS, Kim JH, Yoo SJ, Lew YJ, Kim J. Fellow-eye neovascularization in unilateral retinal angiomatous proliferation in a K orean population. Acta ophthalmologica. 2016;94(1):e49-e53.
72. Lei J, Balasubramanian S, Abdelfattah NS, Nittala MG, Sadda SR. Proposal of a simple optical coherence tomography-based scoring system for progression of age-related macular degeneration. Graefe's Archive for Clinical and Experimental Ophthalmology. 2017;255(8):1551-1558.
73. Ferrara D, Silver RE, Louzada RN, Novais EA, Collins GK, Seddon JM. Optical coherence tomography features preceding the onset of advanced age-related macular degeneration. Investigative ophthalmology & visual science. 2017;58(9):3519-3529.
74. Nassisi M, Fan W, Shi Y, et al. Quantity of intraretinal hyperreflective foci in patients with intermediate age-related macular degeneration correlates with 1-year progression. Investigative ophthalmology & visual science. 2018;59(8):3431-3439.
75. Fragiotta S, Rossi T, Cutini A, Grenga PL, Vingolo EM. Predictive factors for development of neovascular age-related macular degeneration: a spectral-domain optical coherence tomography study. Retina. 2018;38(2):245-252.
76. Cukras C, Agrón E, Klein ML, et al. Natural history of drusenoid pigment epithelial detachment in age-related macular degeneration: Age-Related Eye Disease Study Report No. 28. Ophthalmology. 2010;117(3):489-499.
77. Klein M, Ferris F, Gensler G, et al. Clinical Features and Natural Course of Drusenoid Pigment Epithelial Detachments in Age–related Macular Degeneration. Investigative Ophthalmology & Visual Science. 2004;45(13):3047-3047.
78. Roquet W, Roudot-Thoraval F, Coscas G, Soubrane G. Clinical features of drusenoid pigment epithelial detachment in age related macular degeneration. British journal of ophthalmology. 2004;88(5):638-642.
79. Bailey ST, Thaware O, Wang J, et al. Detection of nonexudative choroidal neovascularization and progression to exudative choroidal neovascularization using OCT angiography. Ophthalmology Retina. 2019;3(8):629-636.
80. de Oliveira Dias JR, Zhang Q, Garcia JM, et al. Natural history of subclinical neovascularization in nonexudative age-related macular degeneration using swept-source OCT angiography. Ophthalmology. 2018;125(2):255-266.
81. Serra R, Coscas F, Boulet JF, et al. Predictive activation biomarkers of treatment-naive asymptomatic choroidal neovascularization in age-related macular degeneration. Retina. 2020;40(7):1224-1233.
82. Hariri A, Nittala MG, Sadda SR. Outer retinal tubulation as a predictor of the enlargement amount of geographic atrophy in age-related macular degeneration. Ophthalmology. 2015;122(2):407-413.
83. Meuer SM, Myers CE, Klein BE, et al. The epidemiology of vitreoretinal interface abnormalities as detected by spectral-domain optical coherence tomography: the beaver dam eye study. Ophthalmology. 2015;122(4):787-795.
84. Denniston A, Murray P. Oxford handbook of ophthalmology. OUP Oxford; 2014.
85. Pang CE, Maberley DA, Freund KB, et al. LAMELLAR HOLE–ASSOCIATED EPIRETINAL PROLIFERATION: A Clinicopathologic Correlation. Retina. 2016;36(7):1408-1412.
86. Pournaras CJ. Retinal oxygen distribution. Its role in the physiopathology of vasoproliferative microangiopathies. Retina (Philadelphia, Pa). 1995;15(4):332-347.
87. Veerappan M, El-Hage-Sleiman A-KM, Tai V, et al. Optical coherence tomography reflective drusen substructures predict progression to geographic atrophy in age-related macular degeneration. Ophthalmology. 2016;123(12):2554-2570.
88. Wu Z, Luu CD, Ayton LN, et al. Optical coherence tomography–defined changes preceding the development of drusen-associated atrophy in age-related macular degeneration. Ophthalmology. 2014;121(12):2415-2422.

List of Figures

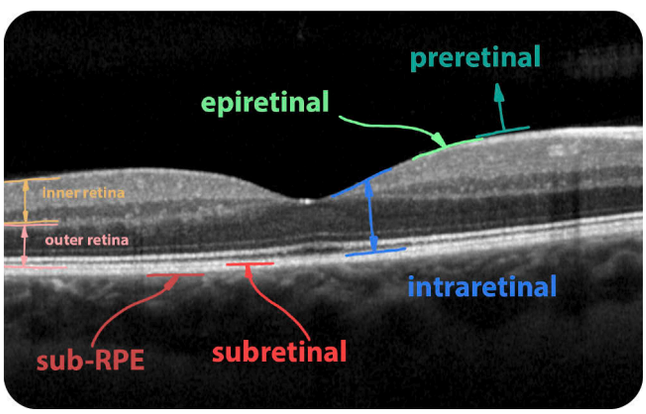
3.Exercise

Especially for the first few cases it would be best if you take the “cheat sheet” and use the assessment guide like you would use a recipe, following one line after another, writing down all the noticeable changes before interpreting them.

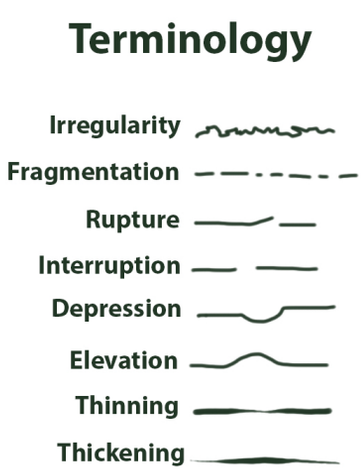
When assessing the scan use the terminology suggested in Fig. 2 and always go back to the scan of the healthy retina when in doubt.



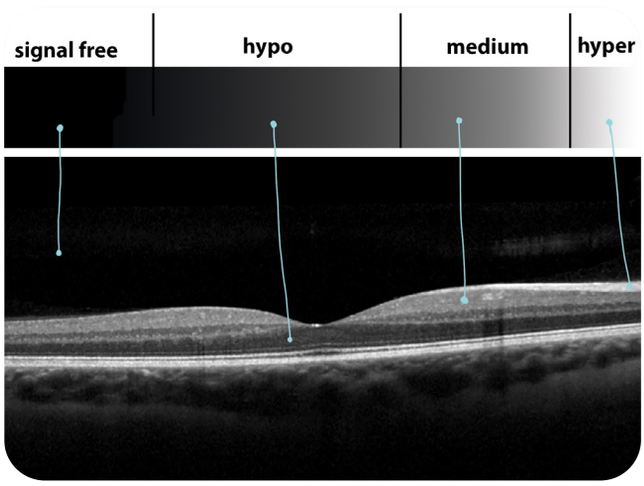
(Fig. 1) Structured process of the OCT assessment



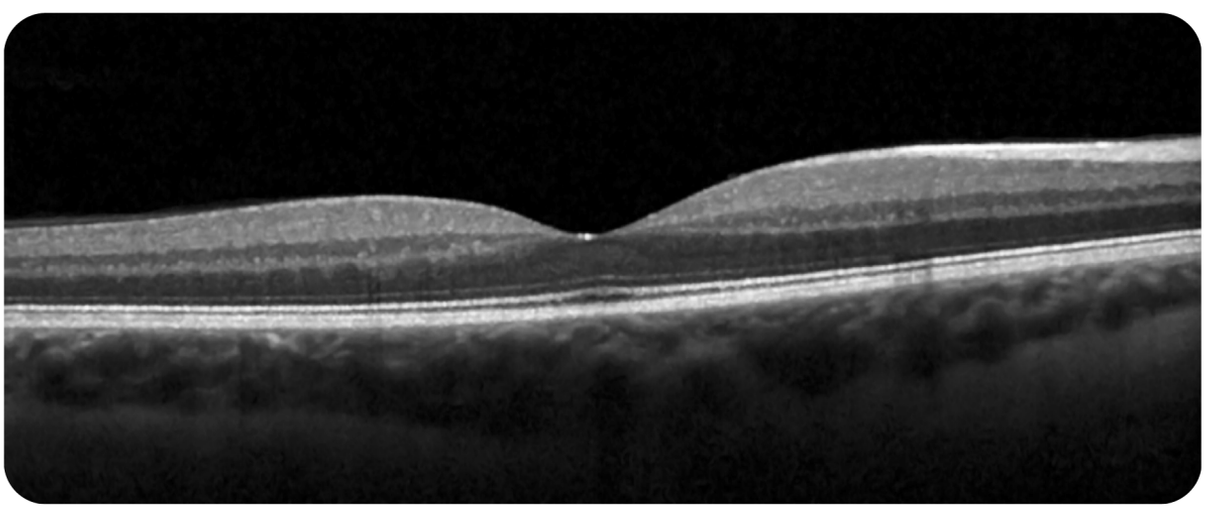
(Fig. 2) Definition of retinal areas



(Fig. 4) Terminology for OCT assessment of alterations

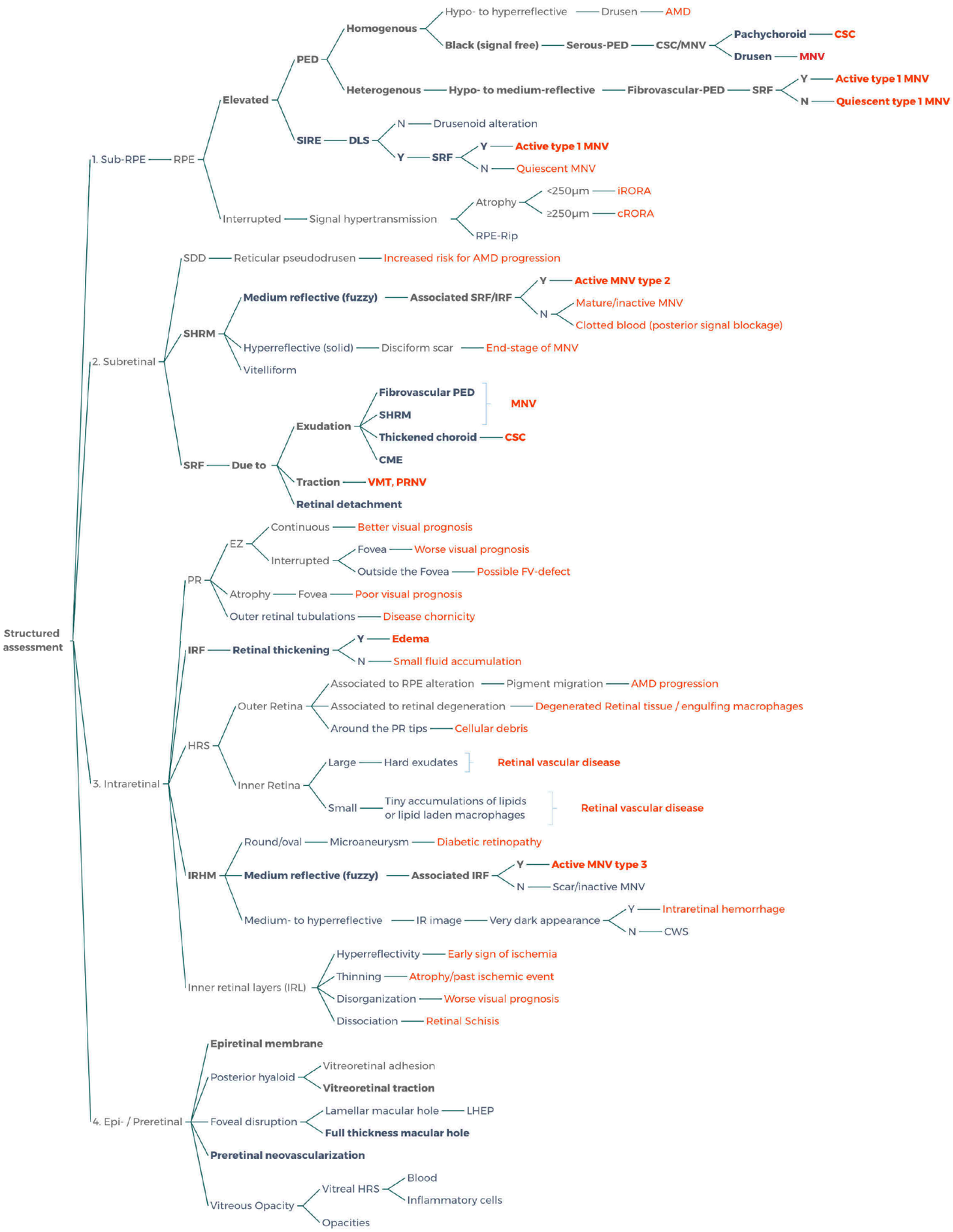


(Fig. 5) Reflective behavior of the individual retinal layers

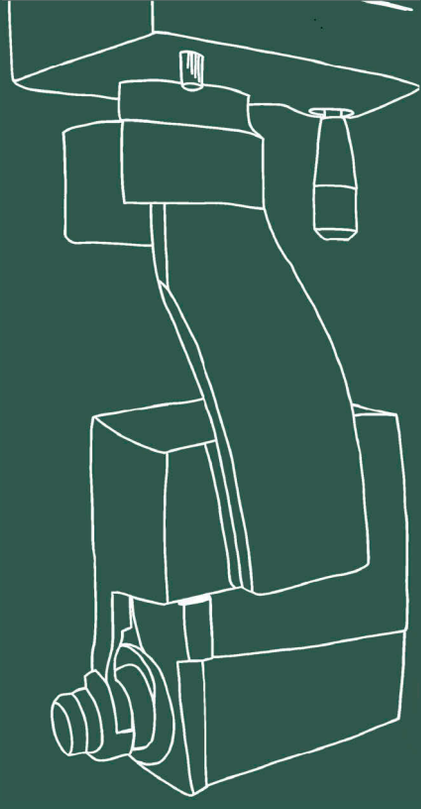


(Fig. 3) OCT scan of a healthy retina

Assessment Guide

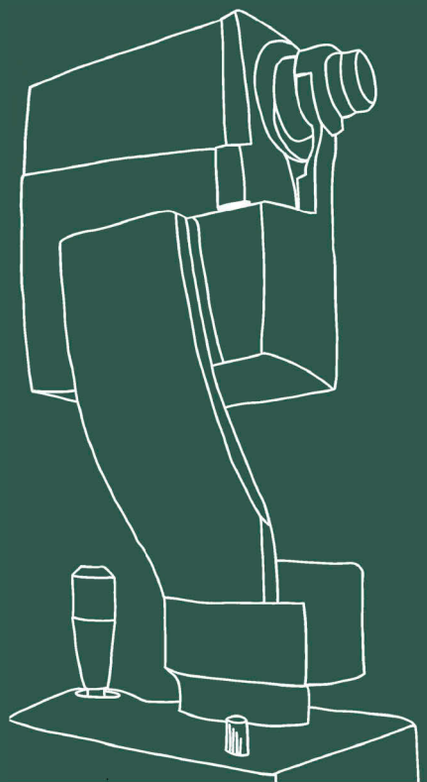


(Fig. 15) Assessment guide



Cases

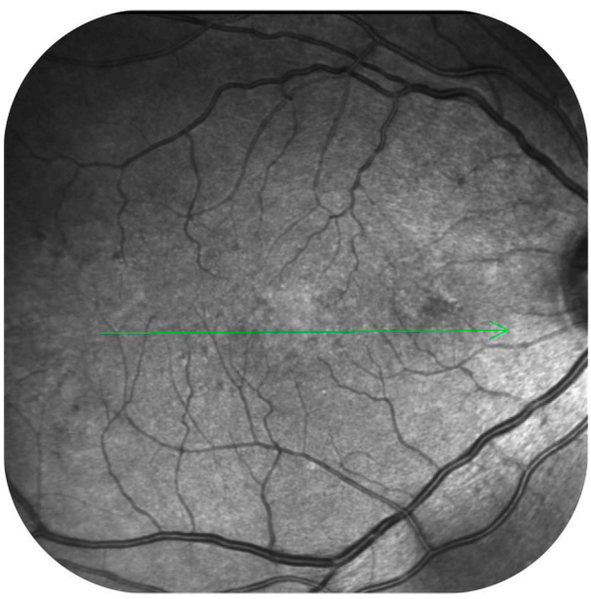
If necessary, use the fold-out
cheat sheets for assistance!



Case 1

Case 1

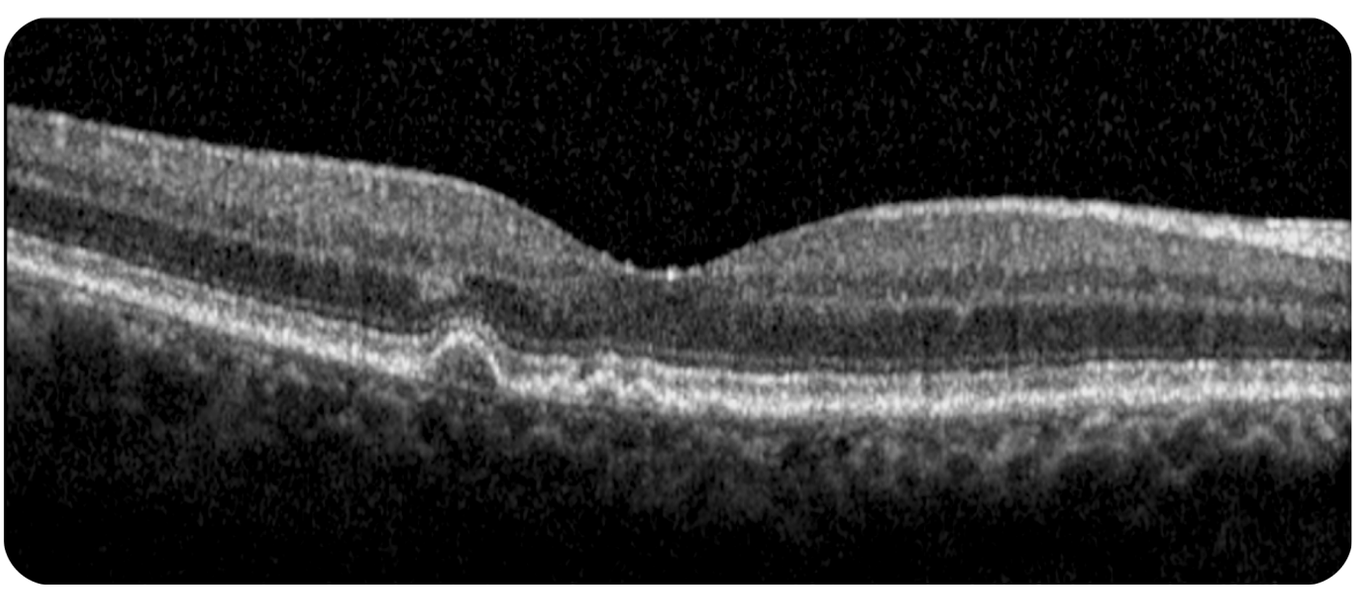
Age 74



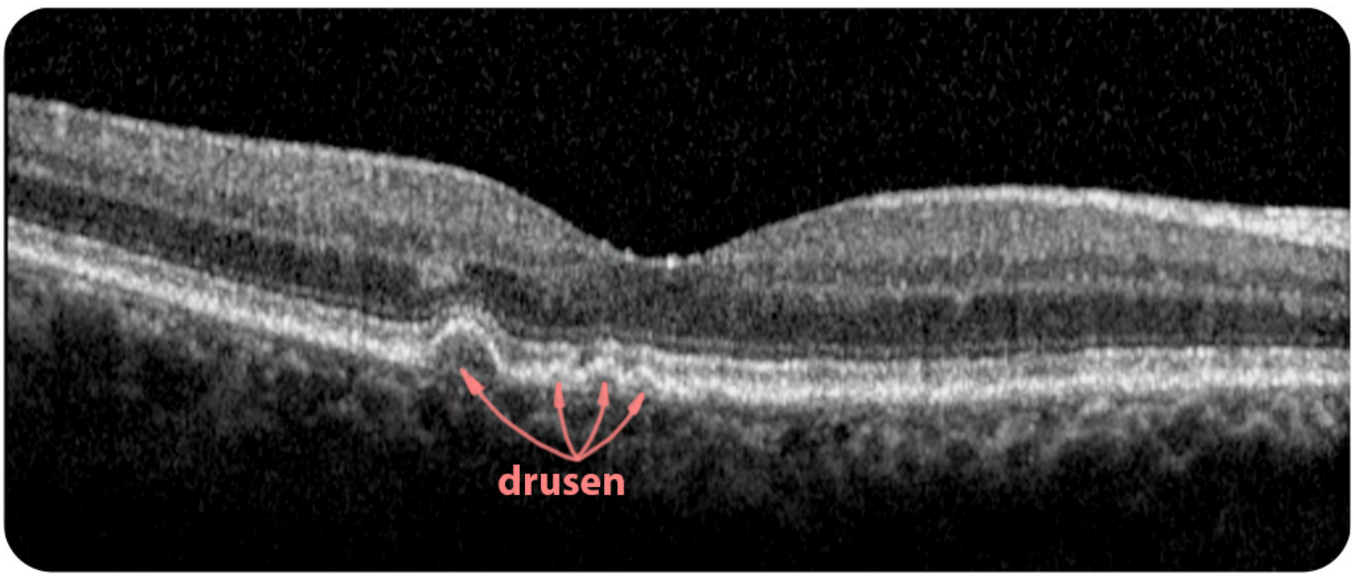
IR Image:
The fovea presents a slightly irregular reflectivity inferiorly.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 1



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	Drusen	Multiple, intermediate and small

Interpretation

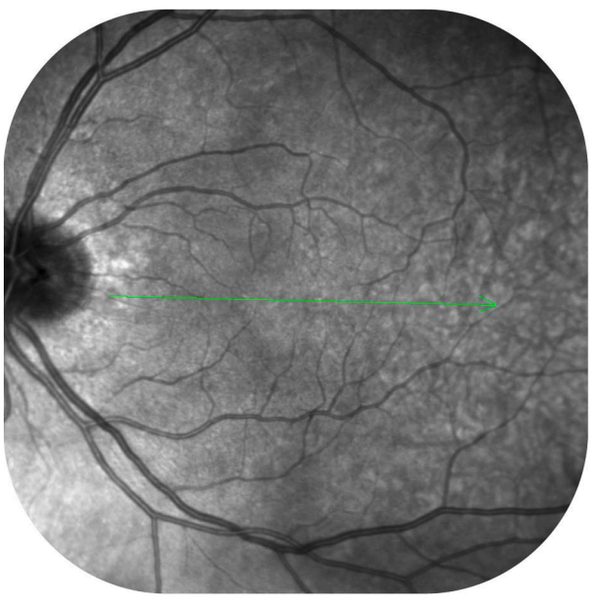
This patient has multiple drusen of varying sizes, consistent with **early AMD**. Although irregular, the EZ is not clearly interrupted, and there is an HFL-RA above the druse.

EZ: Ellipsoid Zone – **HFL-RA**: Henle Fiber Layer - Reflex Artifact – **RPE**: Retinal Pigment Epithelium

Case 2

Case 2

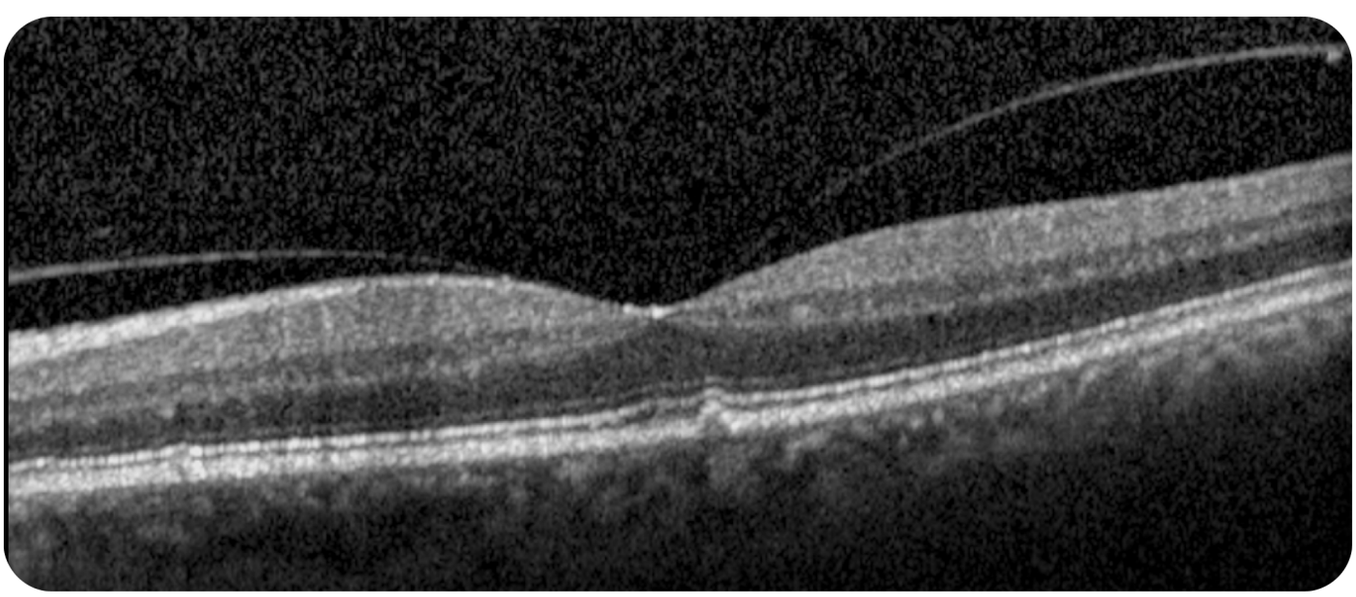
Age 79



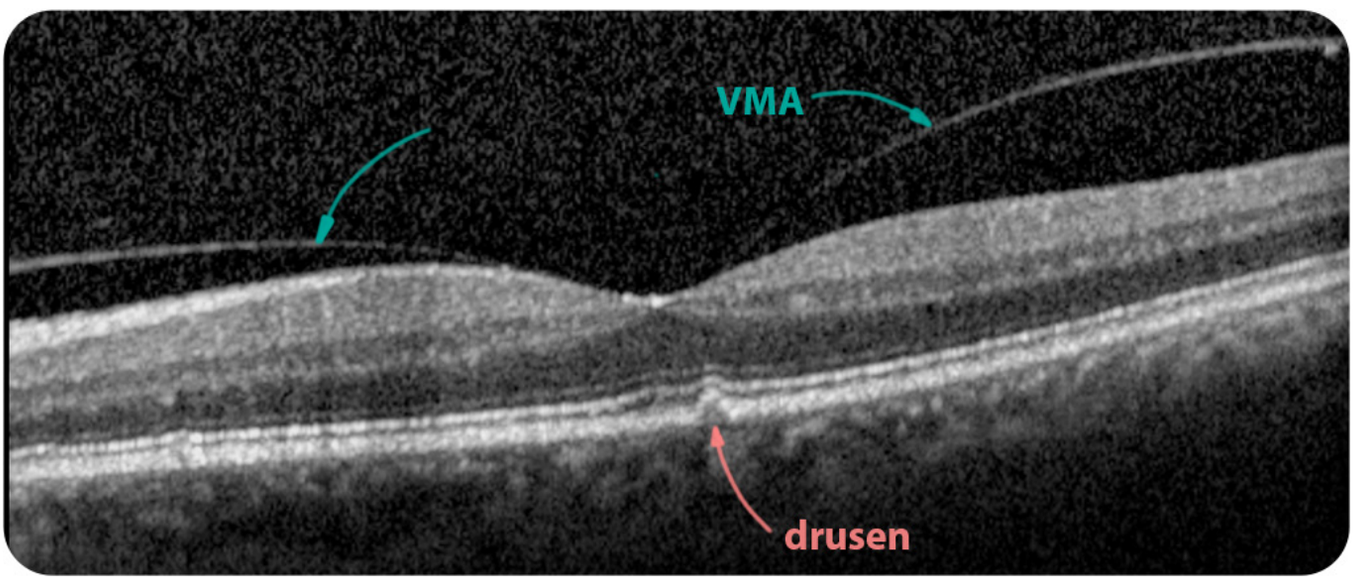
IR Image:
The right half of the image has a somewhat irregular appearance which is most likely caused by an irregular distribution of pigment (norm-variant).

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 2



Findings

Area	Structure	Description
Sub-RPE	RPE	Elevated
	Druse	Single, small druse
Preretinal	VMA	

Interpretation

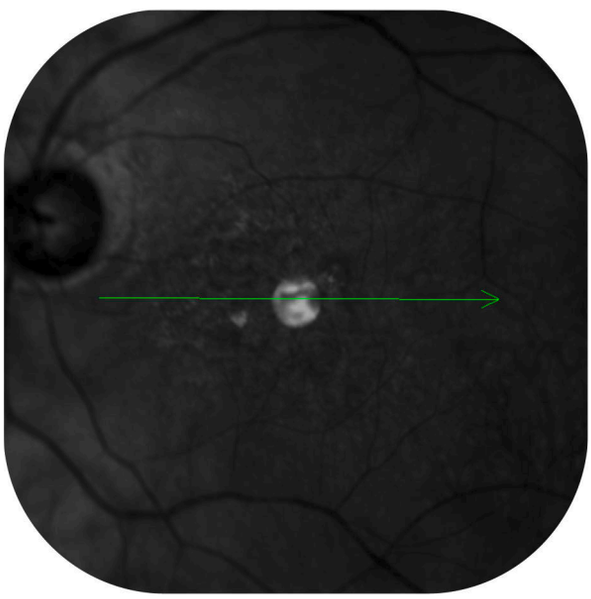
This patient has a single small druse right at the fovea. The vitreous is adherent to the fovea, but it does not cause any traction or deformation of the fovea. So, we are looking at a patient with **early signs of AMD** and a **VMA**.

AMD: Age-related macular degeneration **– RPE**: Retinal Pigment Epithelium – **VMA**: Vitreomacular Adhesion

Case 3

Case 3

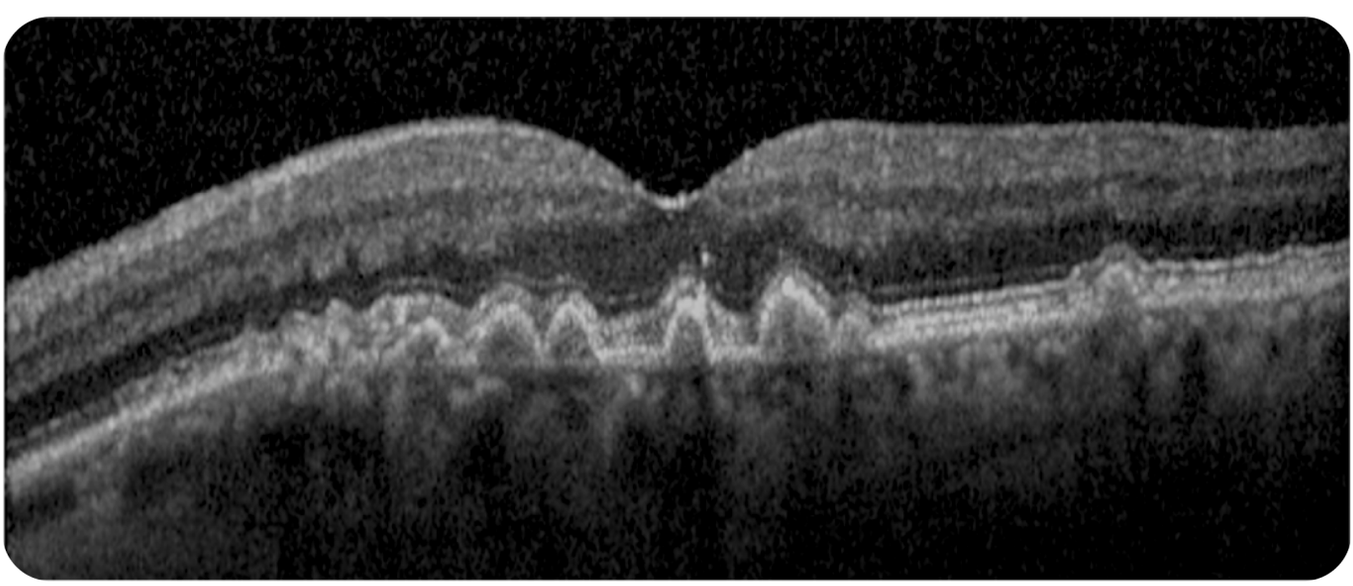
Age 70



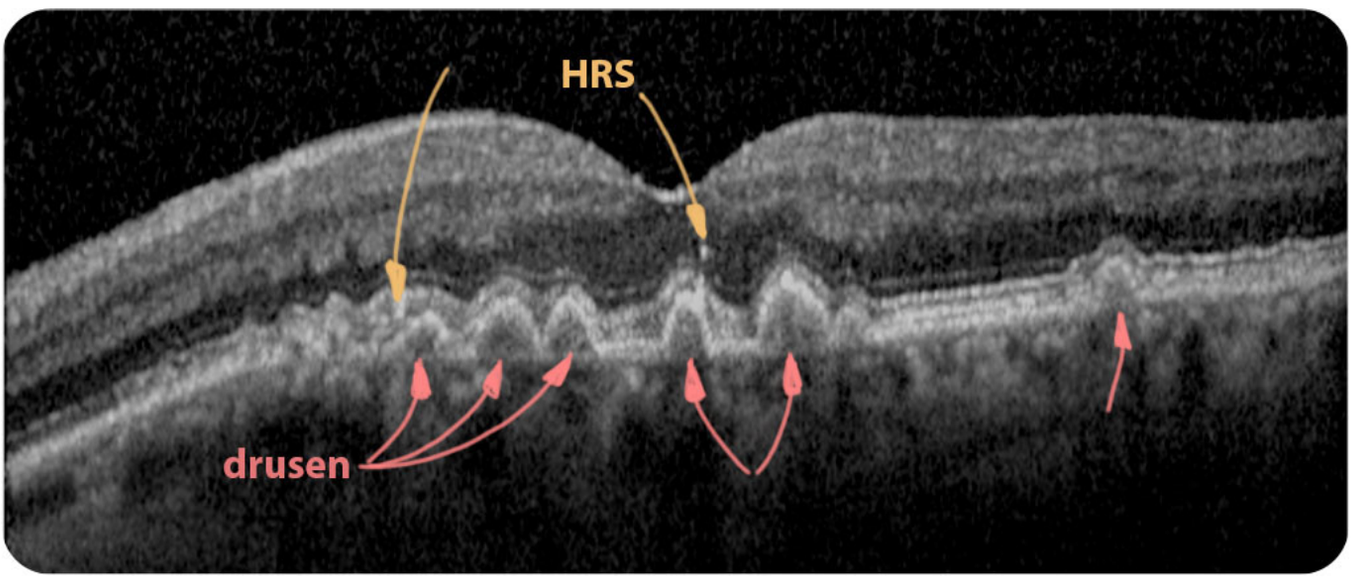
IR Image:
Very dark IR image, insufficient for assessment. However, there is a light-reflex artifact, and if one looks closely, there is a drusen-suspect irregular appearance of the macular region.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 3



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple
Intraretinal	HRS	Associated to RPE alteration

Interpretation

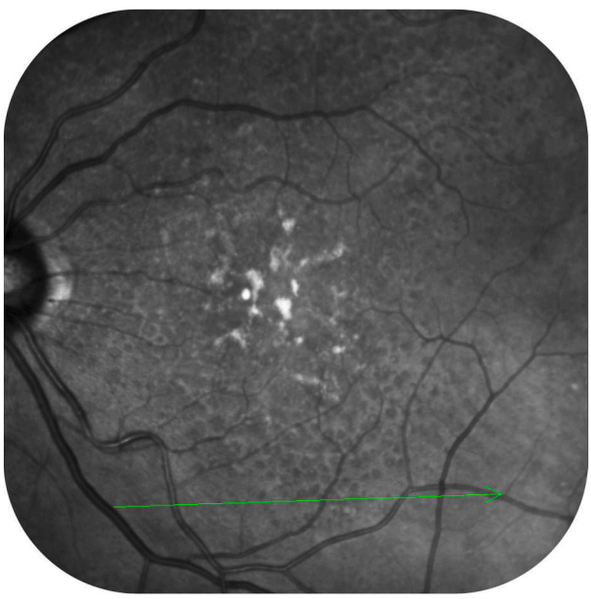
There are multiple drusen of varying sizes spread across the scan – a hallmark of **AMD**. The HRS are associated with the RPE alterations and most likely represent pigment migration, which is a sign of AMD progression.

AMD: Age-related macular degeneration – **RPE**: Retinal Pigment Epithelium – **HRS**: Hyperreflective Spots

Case 4

Case 4

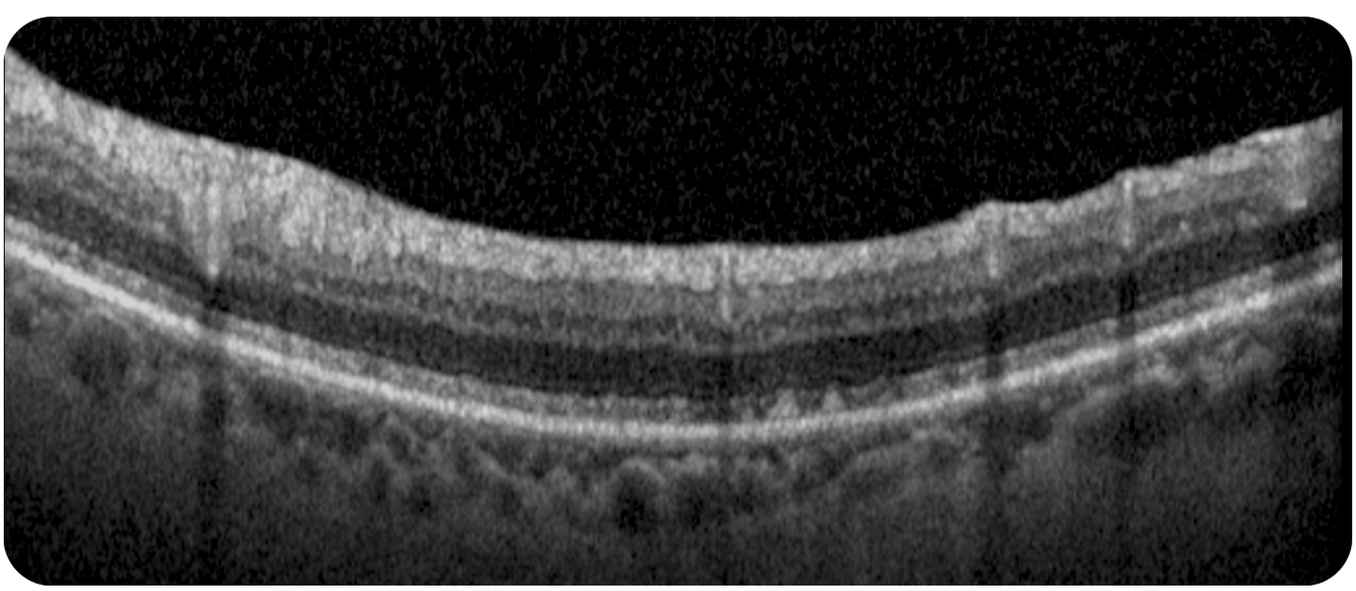
Age 76



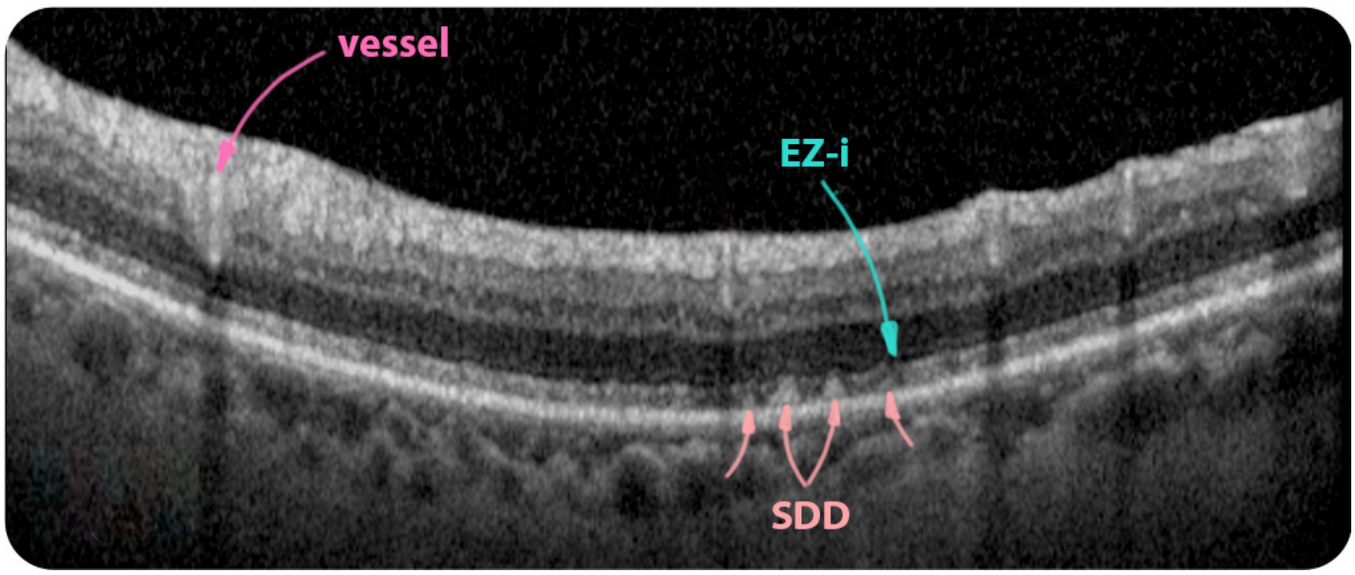
IR Image:
There are disseminated reticular pseudodrusen and the central HRS, in conjunction with the drusen probably represent clumped or migrated pigment.

Scan Quality:
Good with no artifacts

Location:
Peripheral macula



Case 4



Findings

Area	Structure	Description
Sub-RPE	SDD	Reticular pseudodrusen
	PR	EZ interrupted

Interpretation

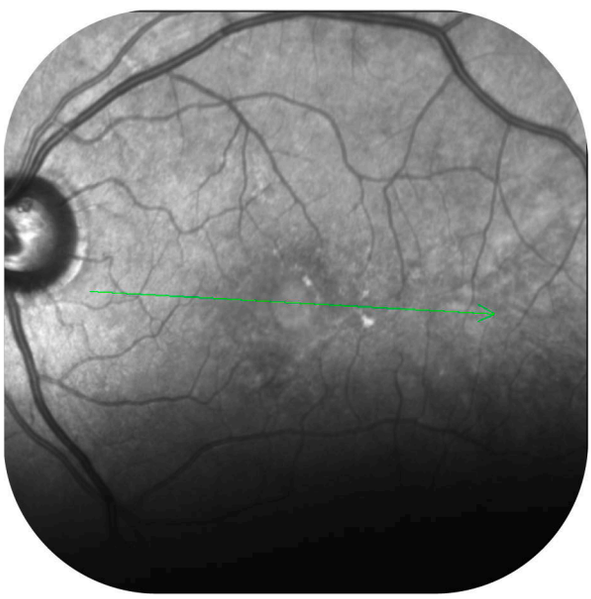
In this scan, we can appreciate well-delineated subretinal drusenoid deposits, of which one has caused an interruption of the EZ. We are looking at a patient with **AMD** who is at a higher risk for MNV development.

AMD: Age-related macular degeneration – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptors – **EZ**: Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **MNV**: Macular neovascularization

Case 5

Case 5

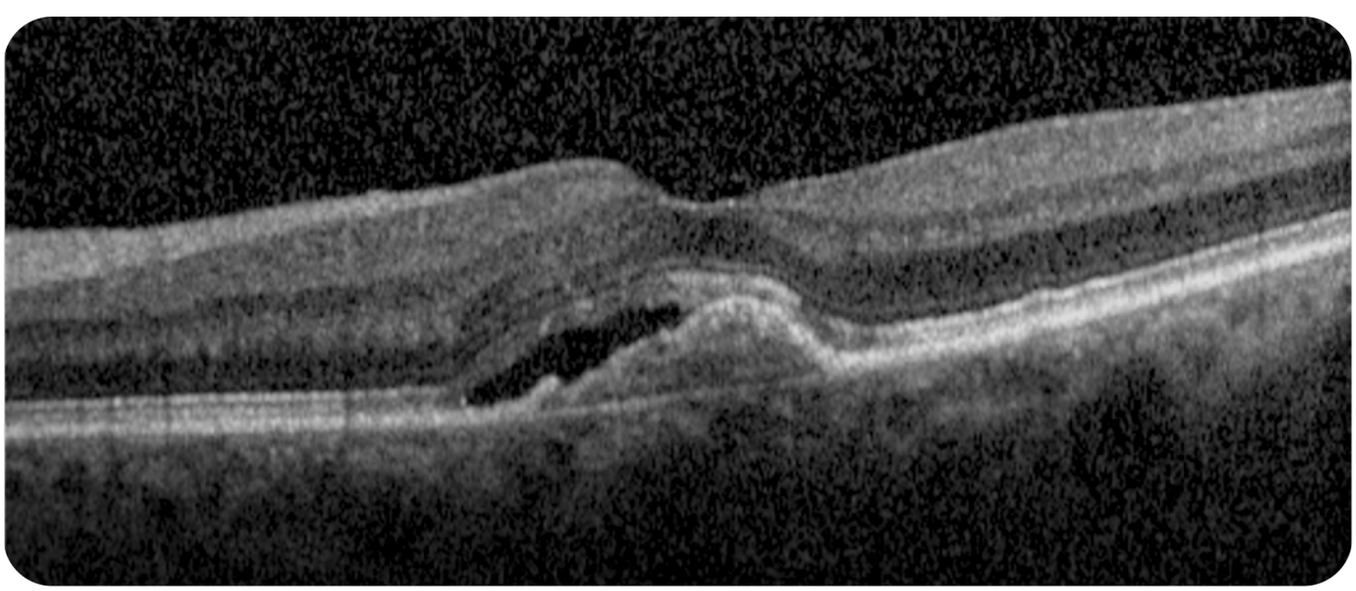
Age 73



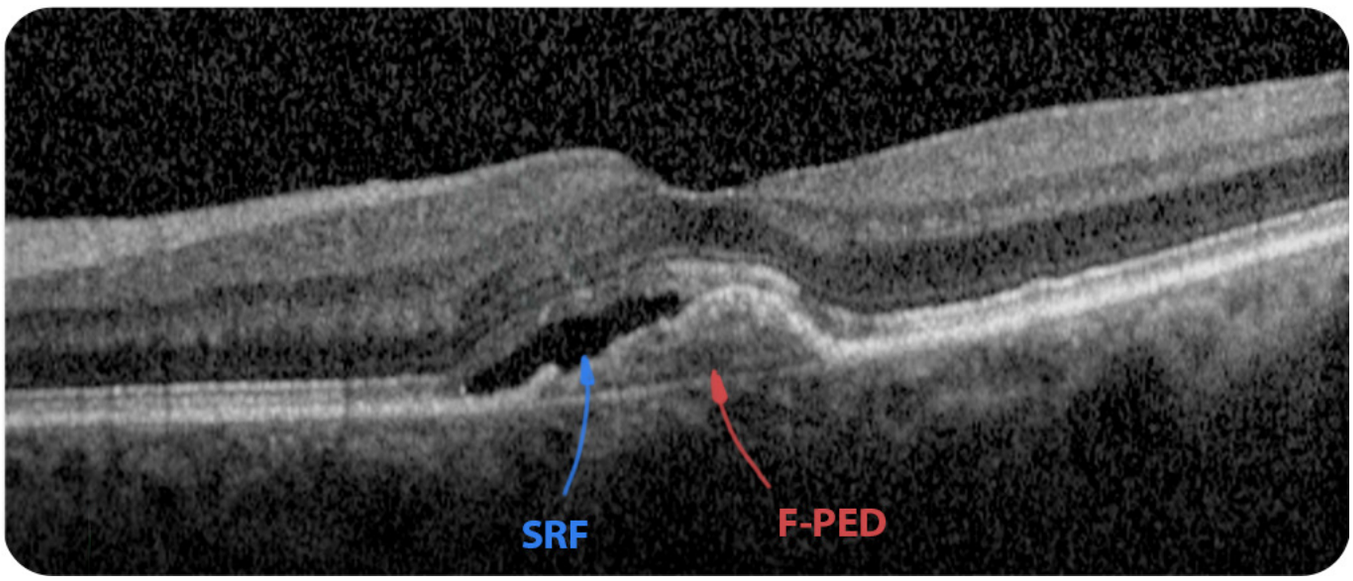
IR Image:
Hyporeflective appearance of the macular region with a central medium reflective circle and multiple bright spots; shadowing artifact in the inferior portion of the image, due to false centration.

Scan Quality:
Good without artifacts

Location:
Fovea



Case 5



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	PED	Fibrovascular PED
Subretinal	SRF	Associated to F-PED

Interpretation

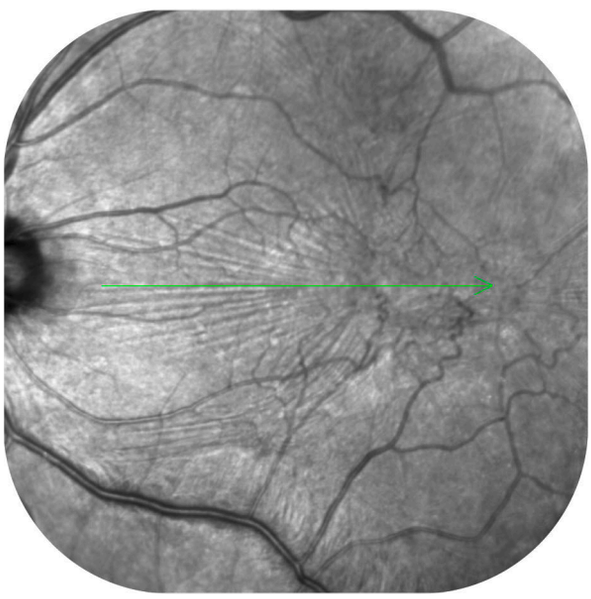
The most striking feature of this eye is heterogenous PED, which is consistent with a fibrovascular PED and is associated with SRF – findings very consistent with an **active type 1 MNV**. There are no clear indications for the underlying condition of the MNV in this scan.

RPE: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **SRF**: Subretinal Fluid – **MNV**: Macular Neovascularization

Case 6

Case 6

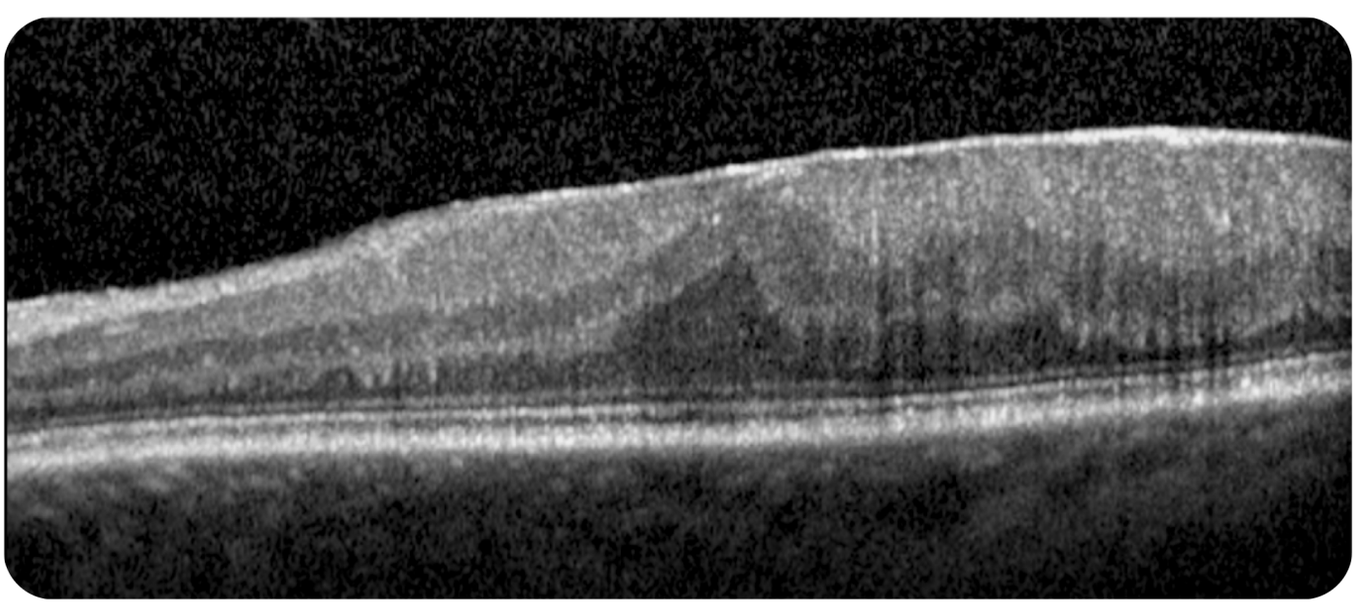
Age 61



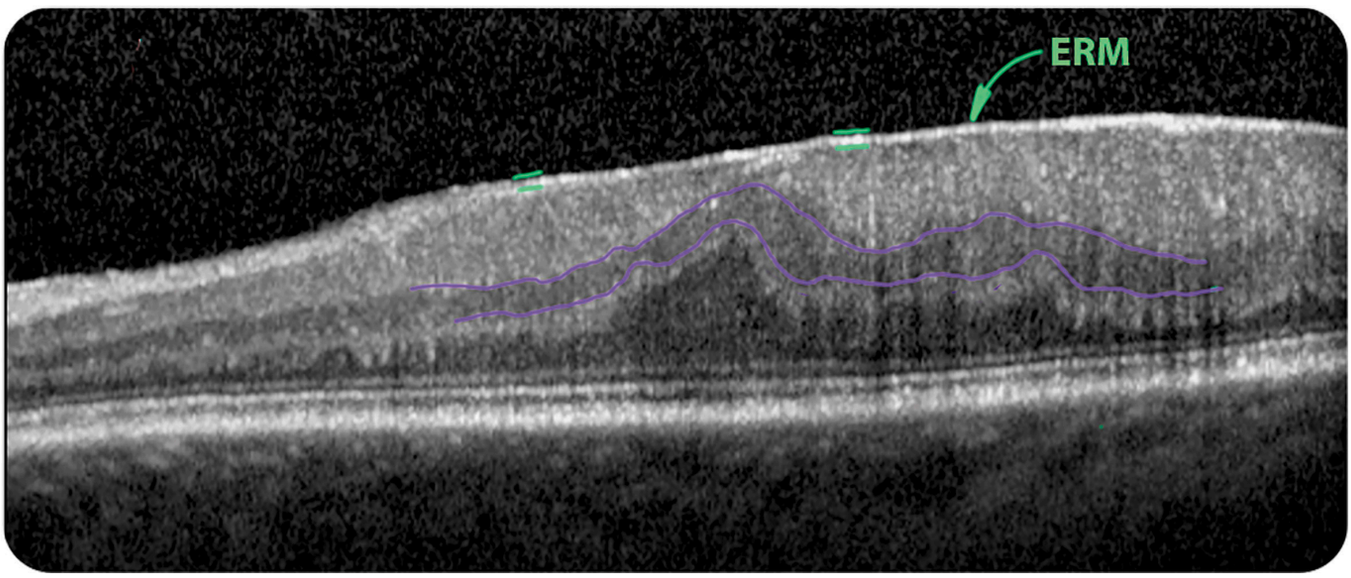
IR Image:
Wrinkling of the retinal surface; otherwise, regular appearance.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 6



Findings

Area	Structure	Description
Epiretinal	ERM	Disorganization of retinal layers

Interpretation

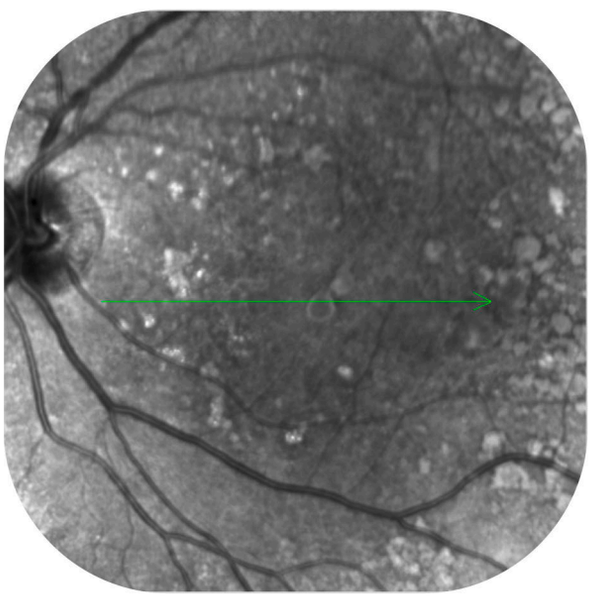
We are looking at a patient with a thick **ERM** that is causing some **disorganization of the retinal layers (DRIL)**.

ERM: Epiretinal Membrane – **DRIL**: Disorganization of Retinal Inner Layers

Case 7

Case 7

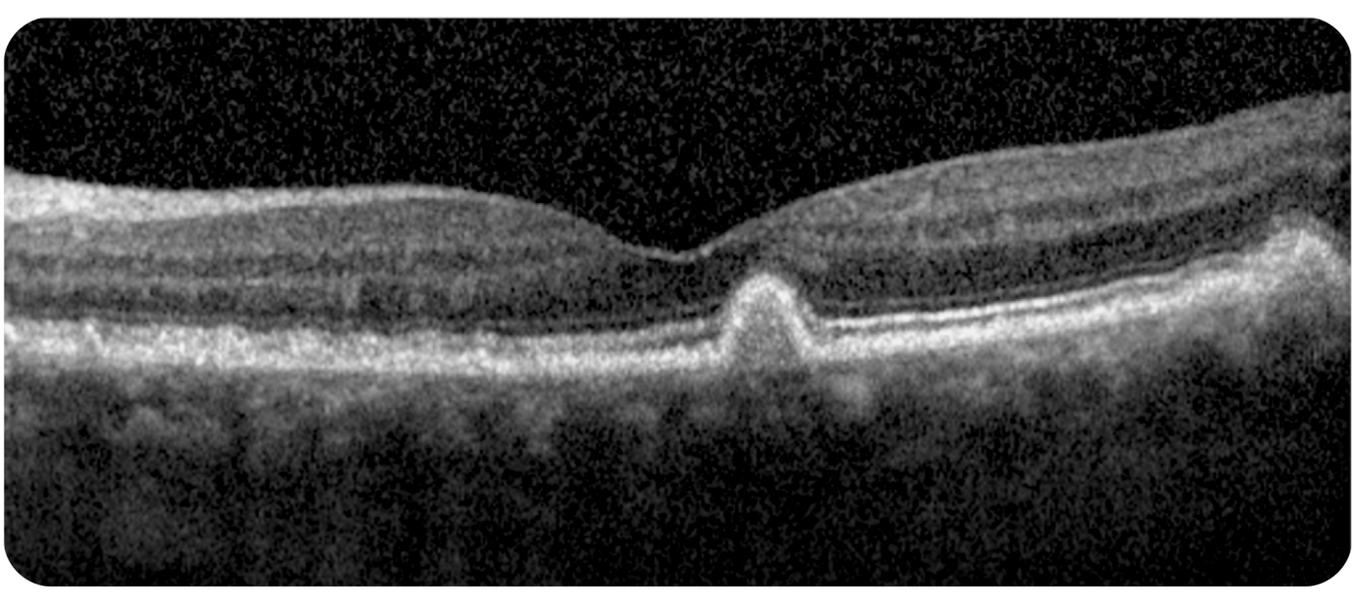
Age 87



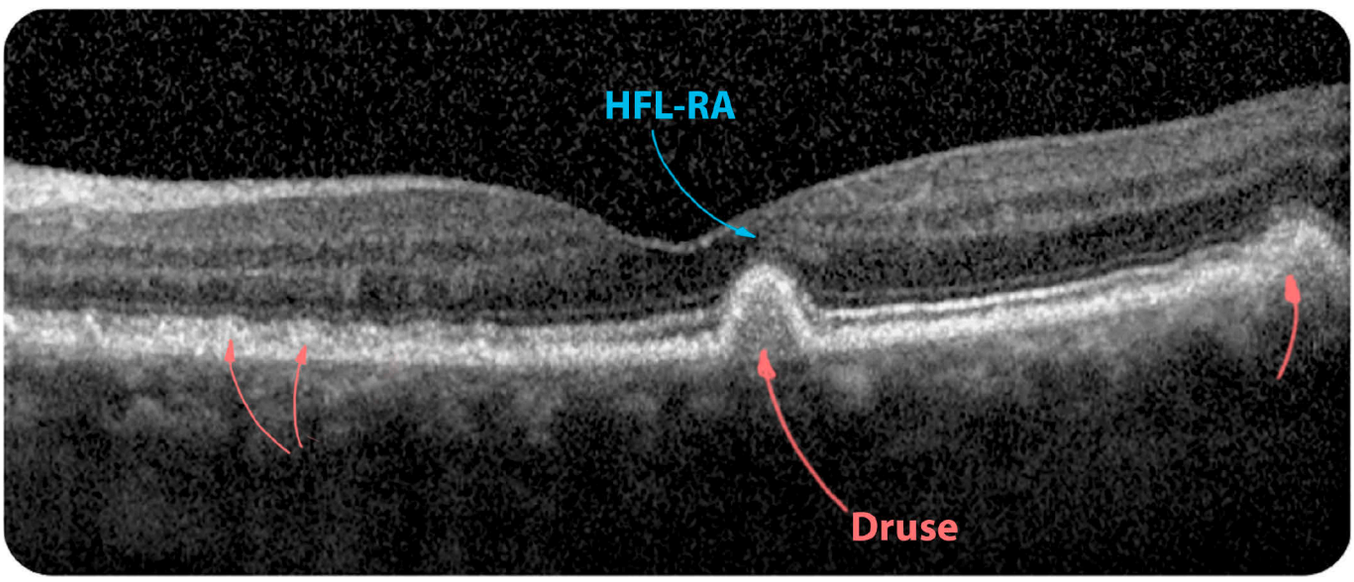
IR Image:
A dark spot with a bright halo right at the fovea consistent with a druse. There are multiple hyperreflective spots and bright areas, predominantly in the extramacular region.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 7



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple of varying sizes

Interpretation

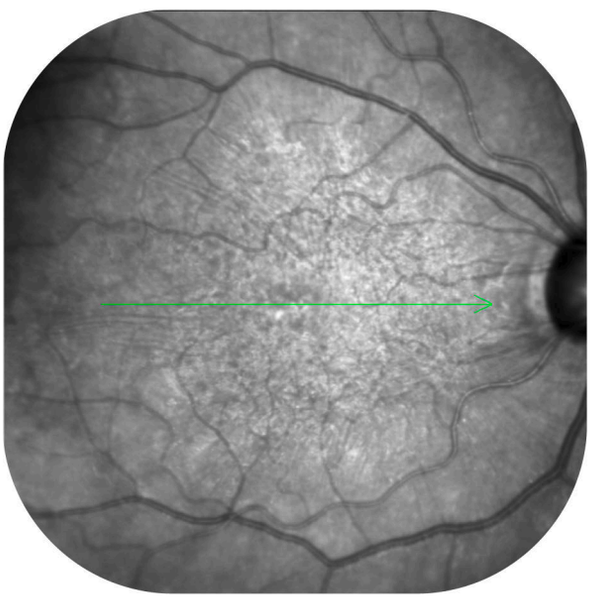
There is a larger druse right at the fovea and on the left side of the scan – we are looking at a patient with **AMD**. The subretinal area on the left side is suspect of SDD or small drusen. The hyperreflective area above the central druse most likely represents an HFL-RA.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **SDD**: Subretinal Drusenoid Deposits - **HFL-RA**: Henle Fiber Layer - Reflex Artifact

Case 8

Case 8

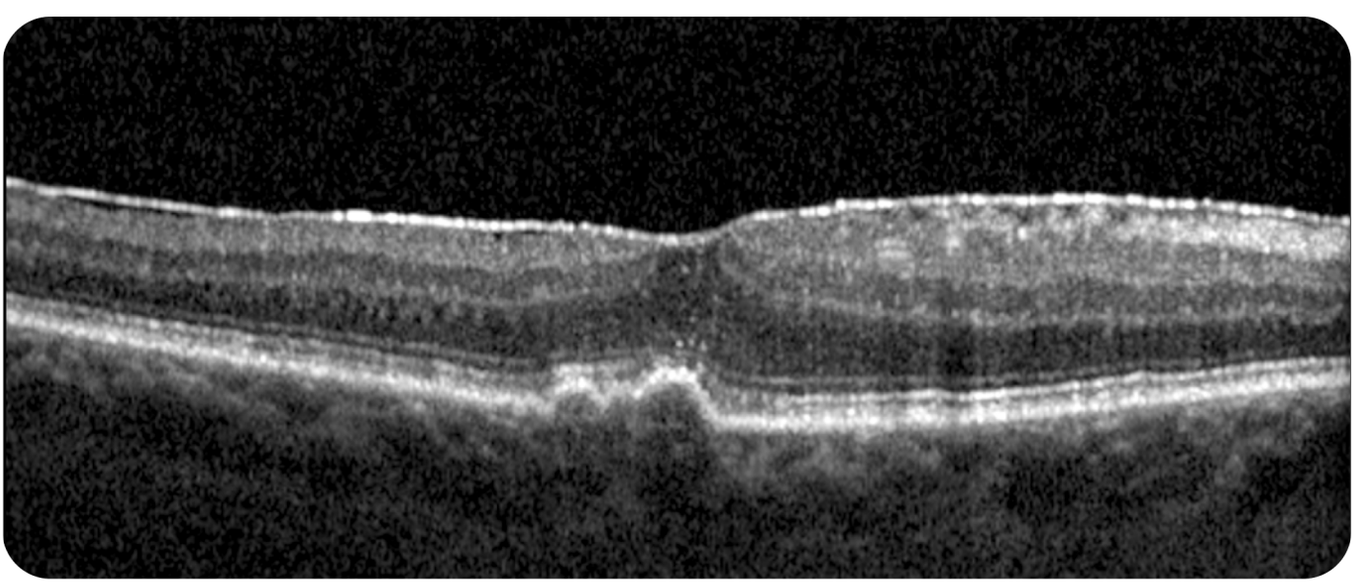
Age 76



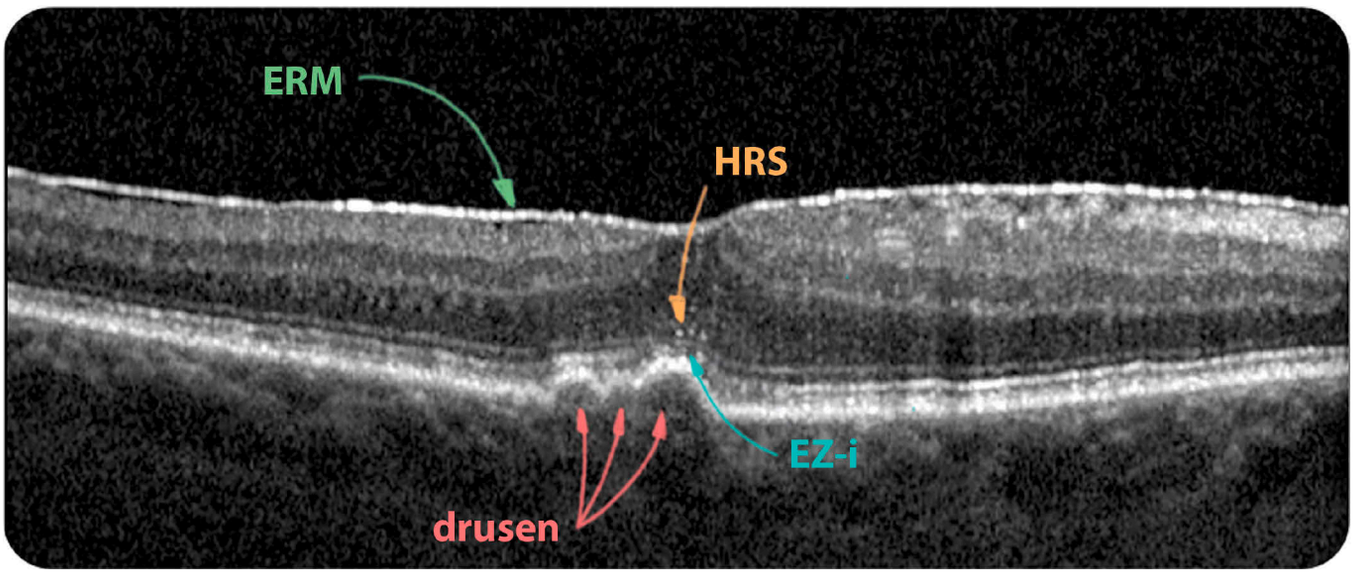
IR Image:
Wrinkling of the retinal surface and irregular appearance of the whole macula.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 8



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple, confluent
Intraretinal	HRS	Associated to RPE alteration
	EZ	Irregular
Epiretinal	ERM	Loss of foveal contour

Interpretation

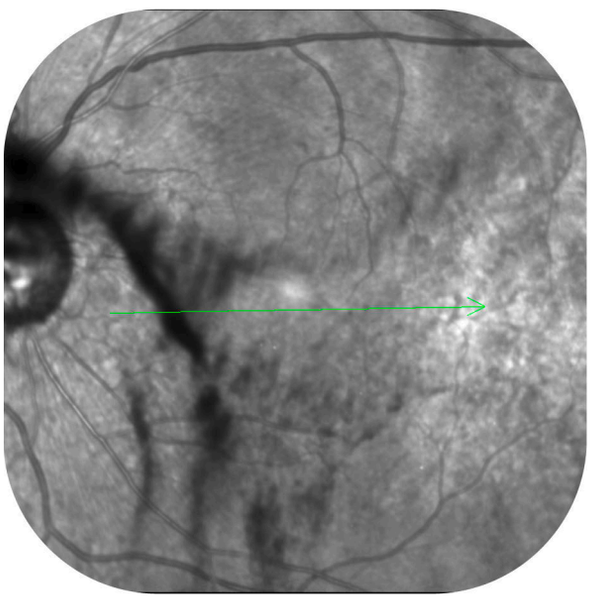
We are looking at a scan with three confluent drusen with associated pigment migration (a sign of **AMD** progression) and an irregular EZ. The **ERM** is causing a deformation of the retina with a loss of the foveal contour.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **HRS**: Hyperreflective Spots – **EZ**: Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **ERM**: Epiretinal Membrane

Case 9

Case 9

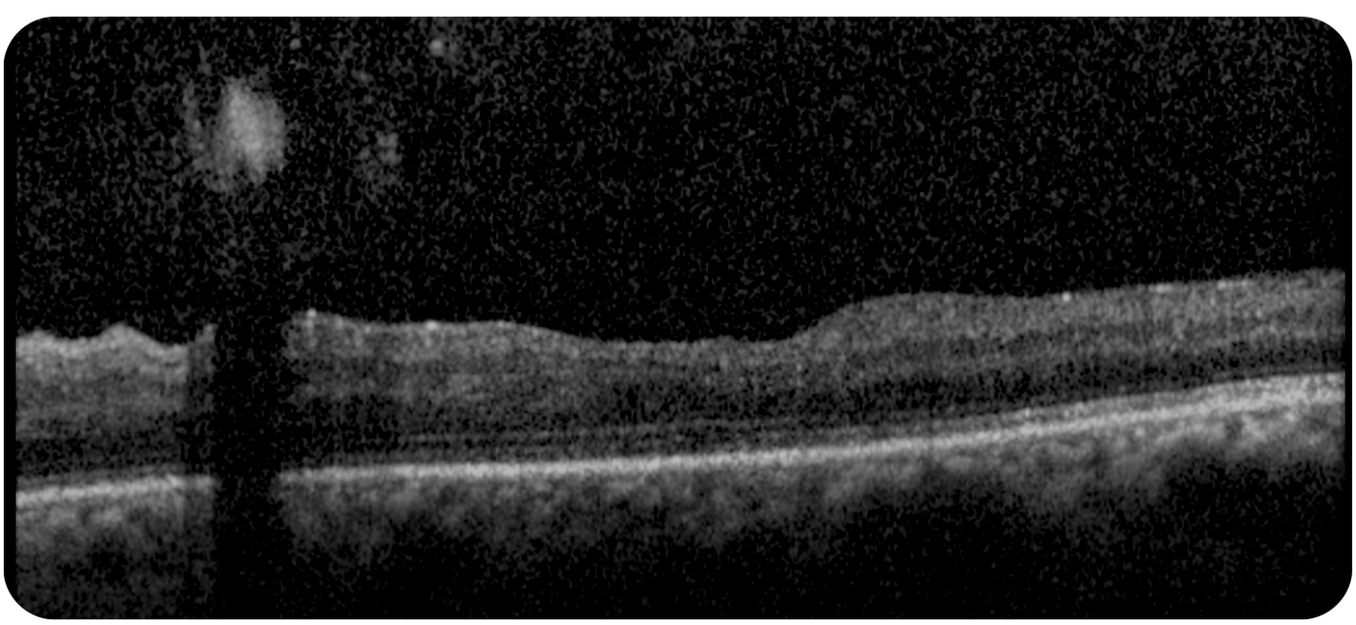
Age 57



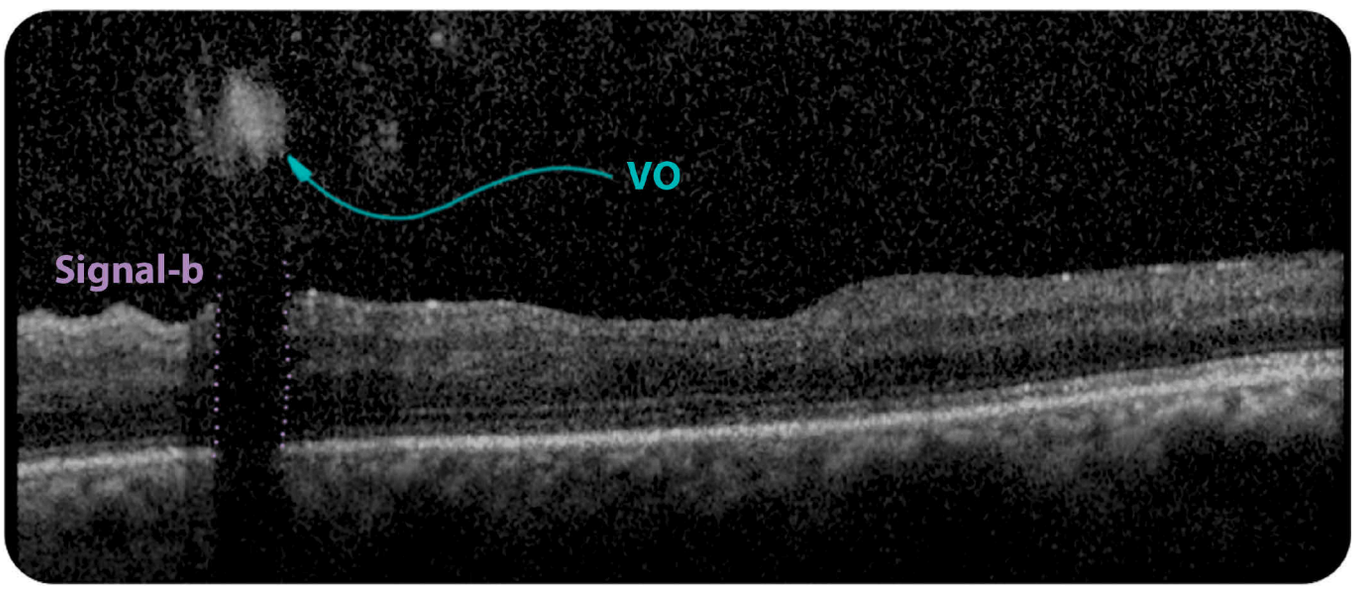
IR Image:
Some wrinkling of the retinal tissue following the superior vascular arcade is visible; there is a dark veil originating from the optic disc.

Scan Quality:
Noisy without artifects

Location:
Parafovea



Case 9



Findings

Area	Alteration	Description
Intraretinal	IRL	Thinned
Preretinal	VO	VO with posterior signal blockage

Interpretation

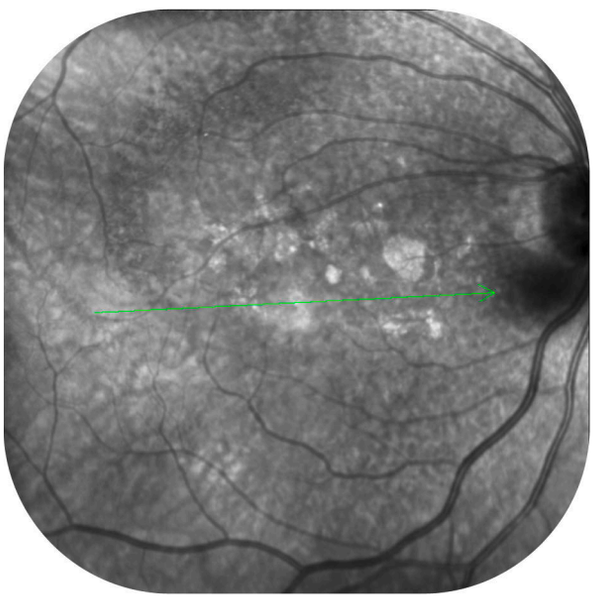
This scan is of inferior quality with ill-defined retinal layers and a large **vitreous opacity** causing a posterior signal blockage (Signal-b). In addition, the retina is relatively thinned, which could indicate a **past ischemic event**.

IRL: Inner Retinal Layers – **VO**: Vitreous Opacity – **Signal-b**: Signal-blockage

Case 10

Case 10

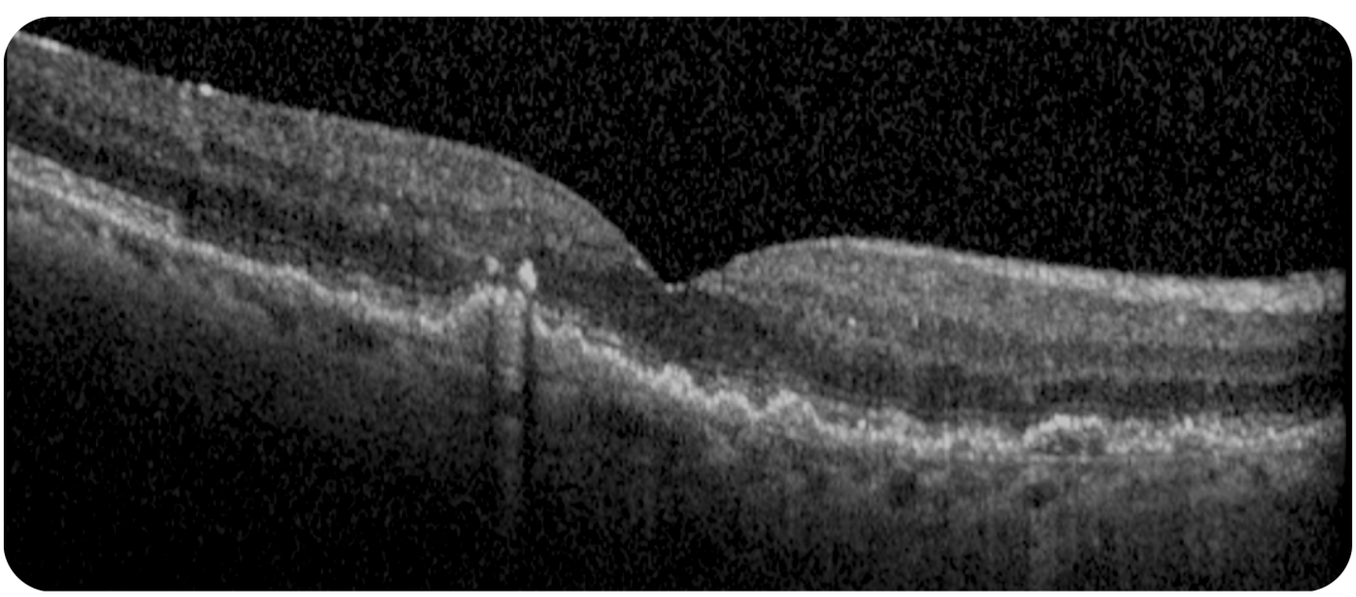
Age 75



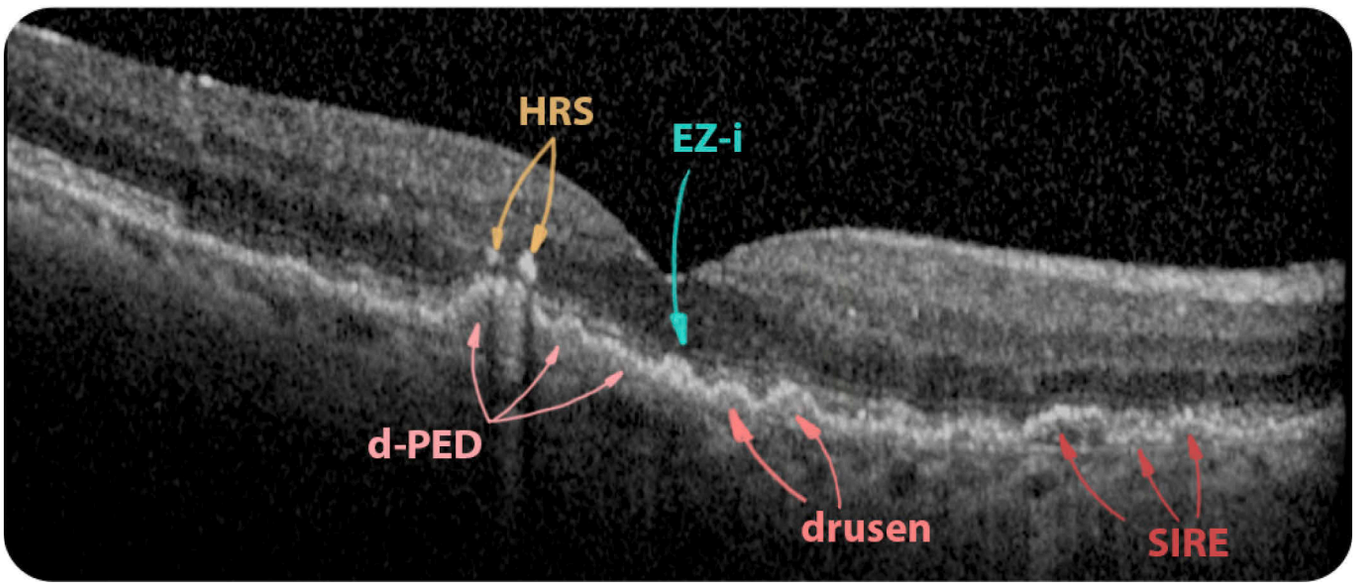
IR Image:
There are multiple hyperreflective spots and areas and disseminated drusen-suspect alterations spread across the macula.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 10



Findings

Area	Alteration	Description
Subretinal	RPE	Elevated, irregular
	PED	Drusenoid PED, drusen
	SIRE	With DLS, no exudation
	PR	EZ and ELM interrupted
Intraretinal	HRS	Associated to alterations of the RPE

Interpretation

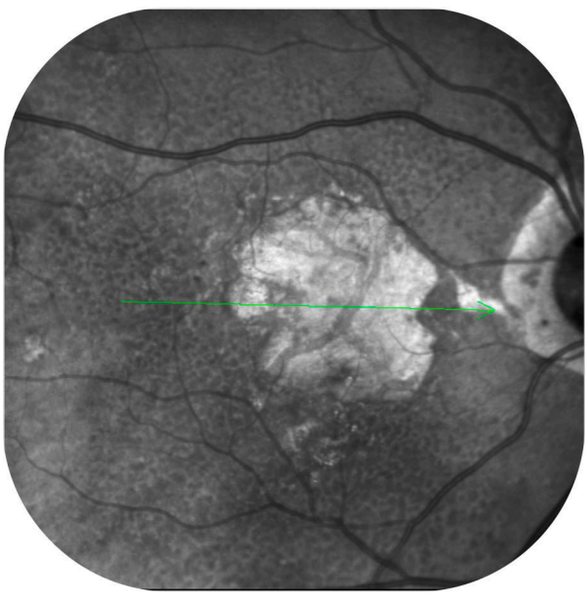
This patient has multiple drusen of varying sizes and features consistent with **AMD**. Centrally there is a drusenoid PED as well as some single drusen. On the right side of the scan, one can appreciate a SIRE without signs of exudation, which could represent a **quiescent MNV** that should be monitored closely. Unfortunately, the EZ and the ELM are interrupted at the fovea, leaving this patient with a comparatively worse visual prognosis. The HRS above the large drusenoid PED likely represent migrated and clumped RPE – a sign of **AMD** progression.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **d-PED:** Drusenoid PED – **SIRE**: Shallow Irregular RPE Elevation – **DLS:** Double-layer sign – **PR**: Photoreceptors – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization – **EZ**: Ellipsoid Zone – **ELM**: External Limiting Membrane

Case 11

Case 11

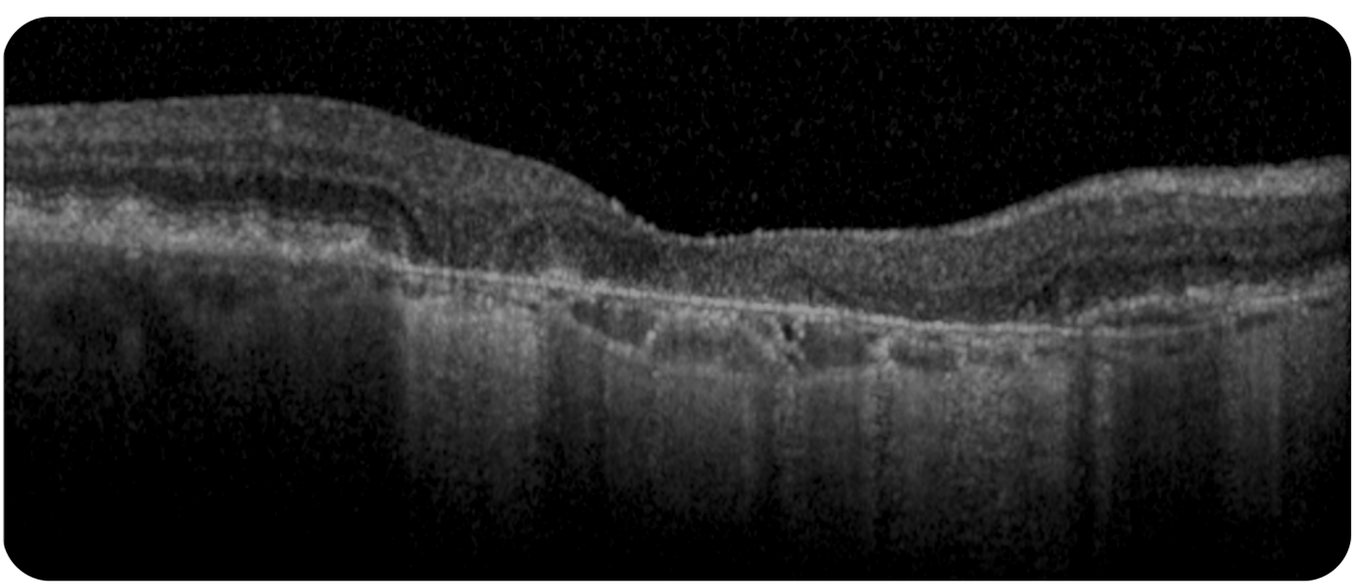
Age 90



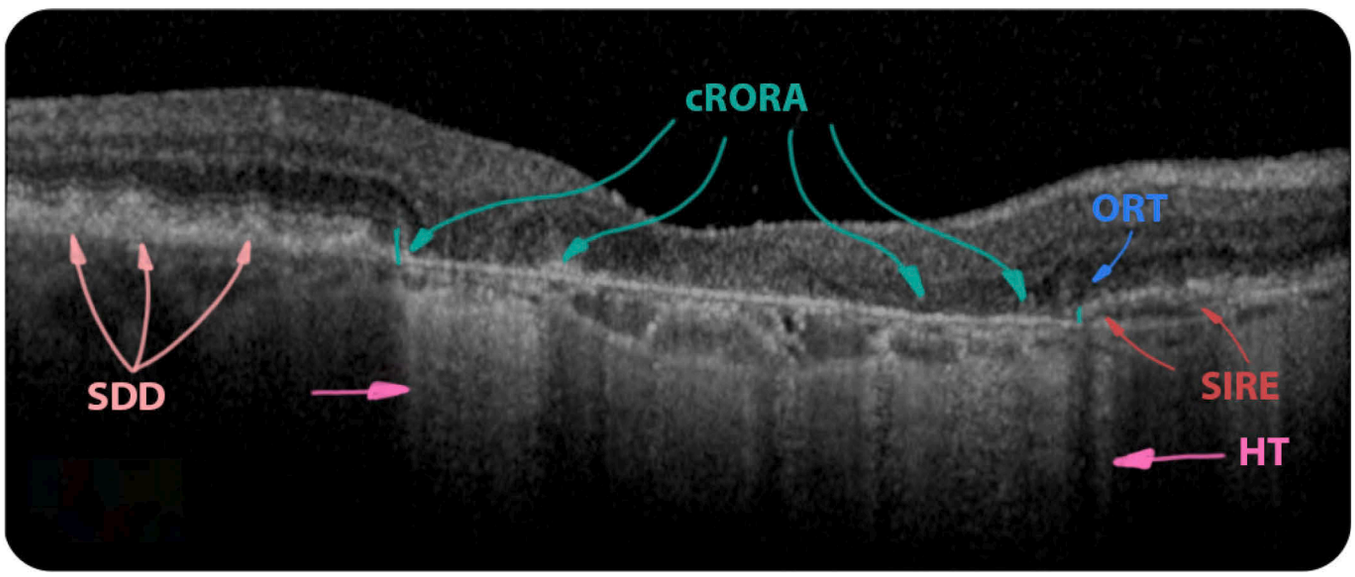
IR Image:
Large bright area with visualized choroidal vessels – consistent with geographic atrophy. Reticular pseudodrusen are spread across the whole fundus.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 11



Findings

Area	Alteration	Description
Sub-RPE	RPE	Interrupted, elevated
	SIRE	With DLS, no exudation
	Atrophy	GA (cRORA)
Subretinal	SDD	Reticular pseudodrusen
	PR	PR atrophy, ORT

Interpretation

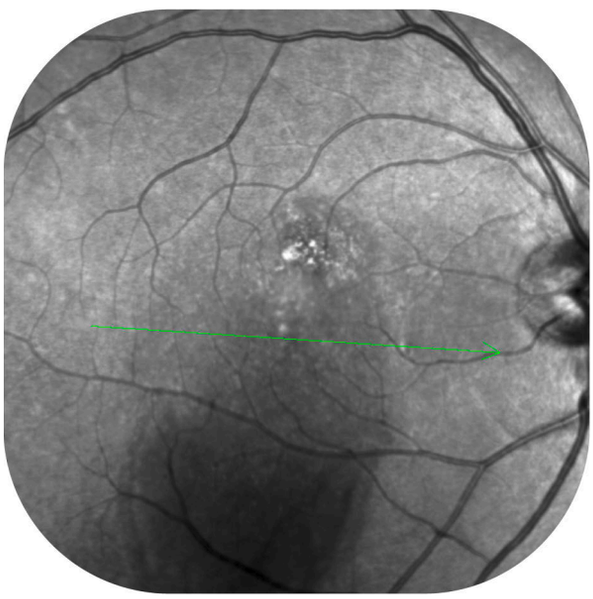
This eye's most striking feature is the widespread area of complete RPE and PR atrophy with adjacent signal hypertransmission (**cRORA**). In addition, on the left side of the scan, there are multiple SDD. A suspect ORT indicates disease chronicity and stability; next to it is a SIRE with an evident DLS without signs of fluid accumulation. These findings are very consistent with a **GA secondary to AMD**. Lastly, the choroid is relatively thinned**.**

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **DLS:** Double-layer sign – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptor – **cRORA**: complete RPE and Outer Retinal Atrophy – **ORT**: Outer Retinal Tubulation – **DLS**: Double Layer Sign – **GA**: Geographic Atrophy – **HT**: Hypertransmission

Case 12

Case 12

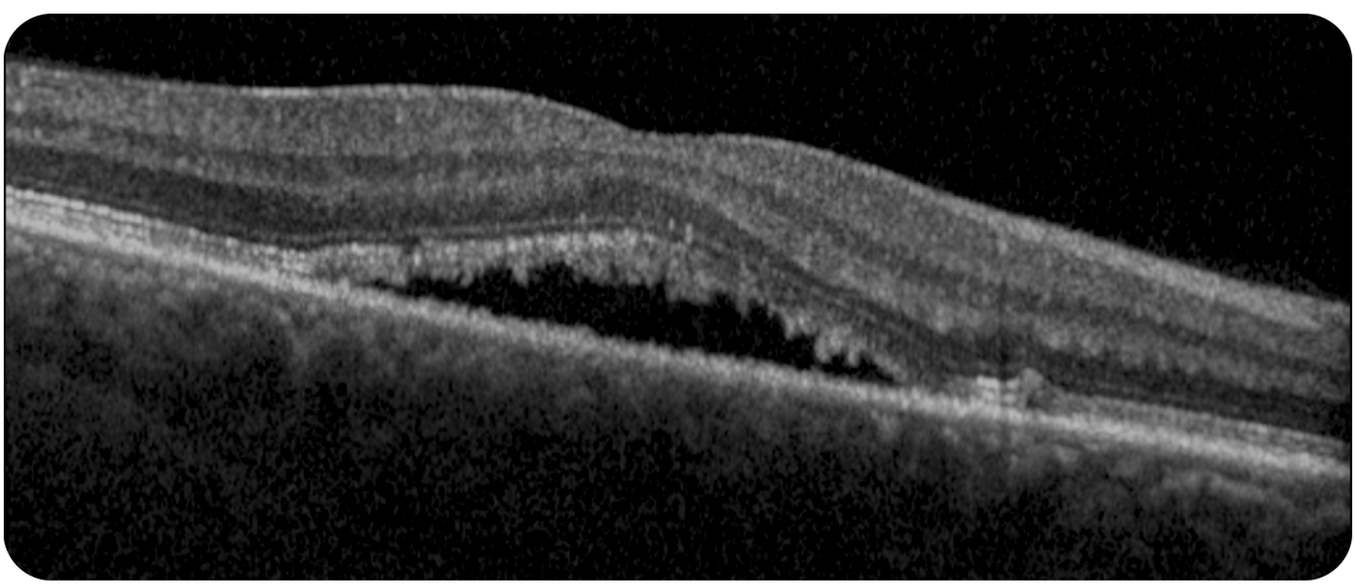
Age 50



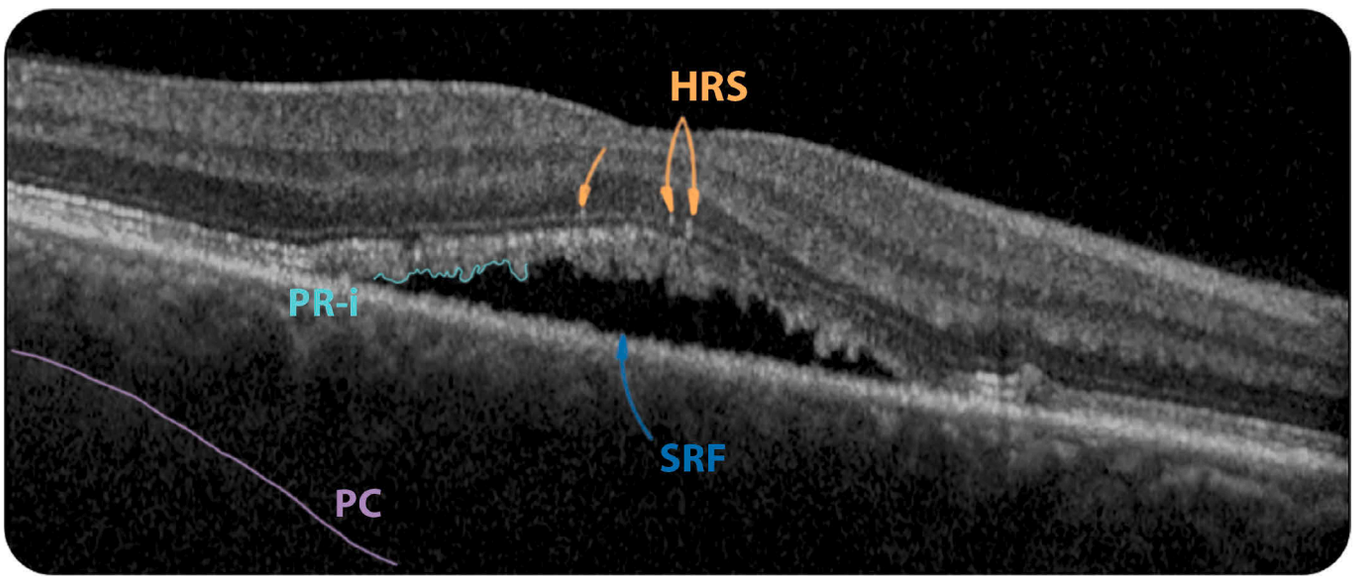
IR Image:
Large hyporeflective area that extends into the lower part of the fundus. In addition, right above the fovea is an accumulation of irregular hyperreflective spots.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 12



Findings

Area	Alteration	Description
Sub-RPE	PC	Suspicious of Pachychoroid (PC)
Subretinal	SRF	Exudation
	PR	Irregularity/Granulated appearance
Intraretinal	HRS	Around the ELM

Interpretation

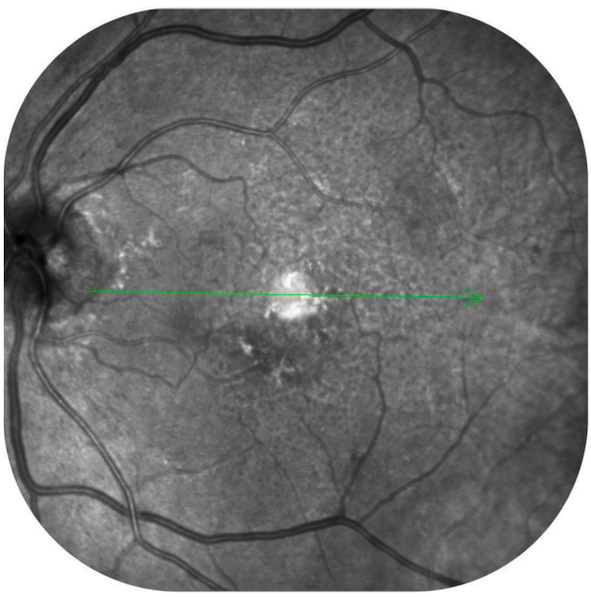
The most striking feature of this scan is the accumulation of SRF. In conjunction with the suspiciously thickened choroid, this patient is probably suffering from a **central serous chorioretinopathy**. The PRs have a granulated, irregular appearance which could represent elongated or shed PR outer segments or fibrin material. The HRS around the ELM could be signs of retinal degeneration.

PC: Pachychoroid – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **PR-i**: Photoreceptor Irregularity – **HRS**: Hyperreflective Spots – **ELM**: External Limiting Membrane

Case 13

Case 13

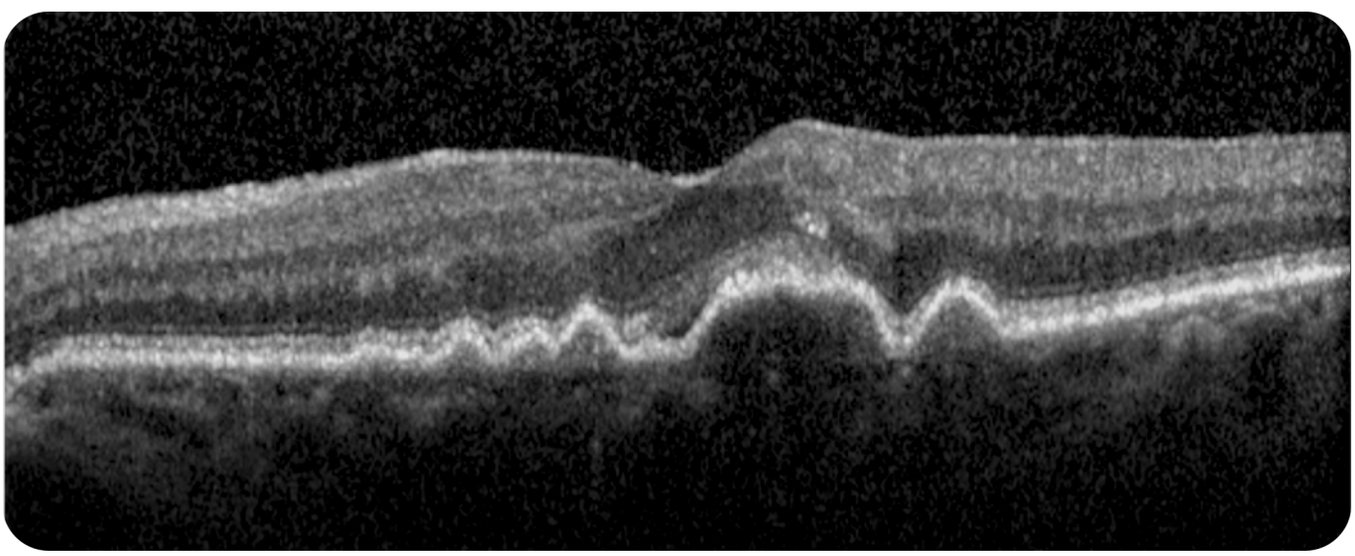
Age 73



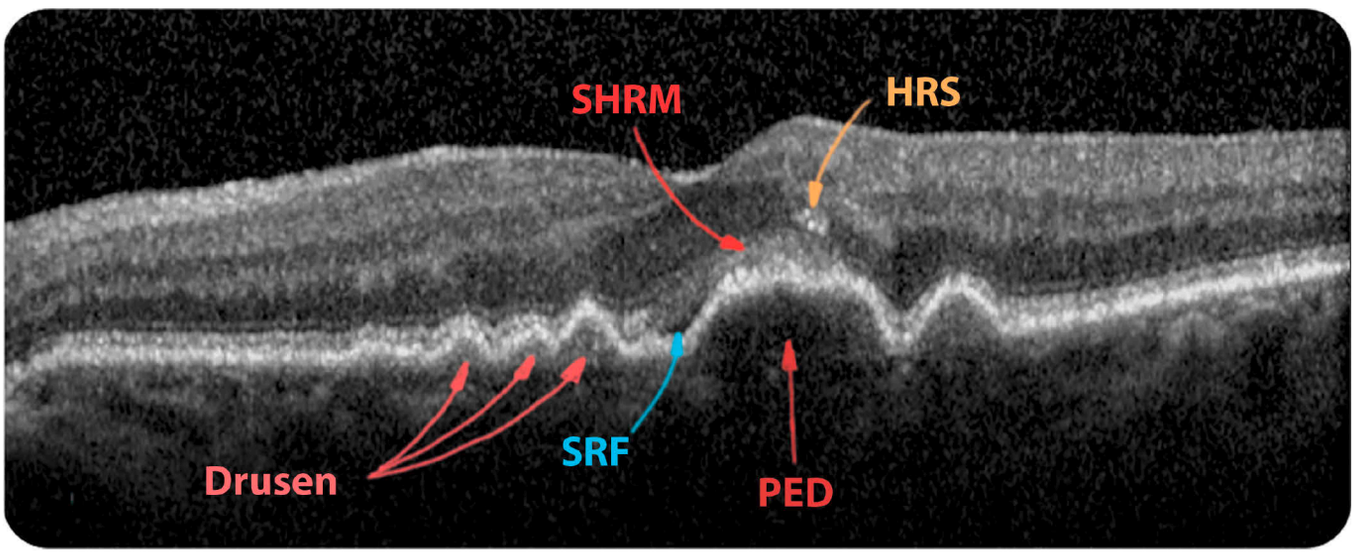
IR Image:
Irregular appearance of the macular region consistent with drusen; there is a darker area in the inferior part of the parafoveal macula and a light-reflex artifact right in the center. Widespread areas of reticular pseudodrusen.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 13



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Drusen; hyporeflective PED
Subretinal	SHRM	Suspicious
	SRF	Suspicious
Intraretinal	HRS	Associated to RPE alteration

Interpretation

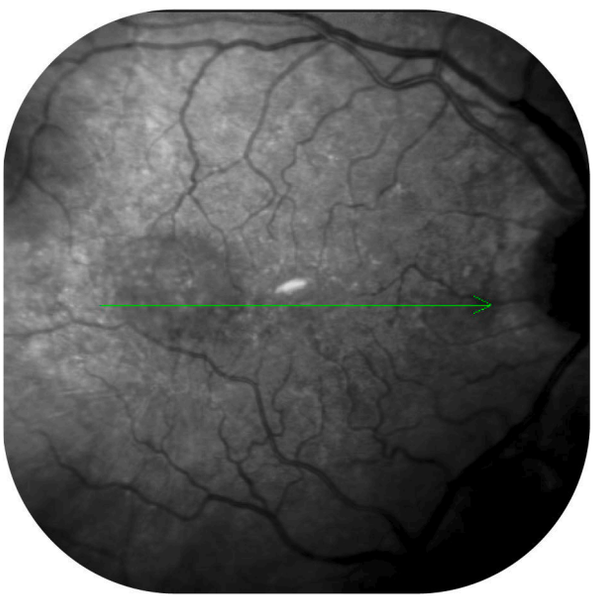
This is an ambiguous case that leaves room for multiple interpretations. The large hyporeflective PED neither has the classic heterogeneous appearance of a F-PED nor the black appearance of a S-PED; however, it is associated with SHRM and an SRF-suspect area pointing towards an MNV. The SRF accumulation could result from a neurosensory detachment caused by the huge PED and only represent pseudo-SRF. As drusen are the hallmark of **AMD** we can confidently diagnose it. However, in this case, OCT-A or FA would be advisable to rule out an MNV. The HRS in this constellation most likely represents pigment migration – a sign of AMD progression.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **HRS**: Hyperreflective Spots – **F-PED**: Fibrovascular-PED – **S-PED**: Serous-PED – **OCT-A:** Optical Coherence Tomography Angiography – **FA**: Fluorescein Angiography – **MNV:** Macular Neovascularization

Case 14

Case 14

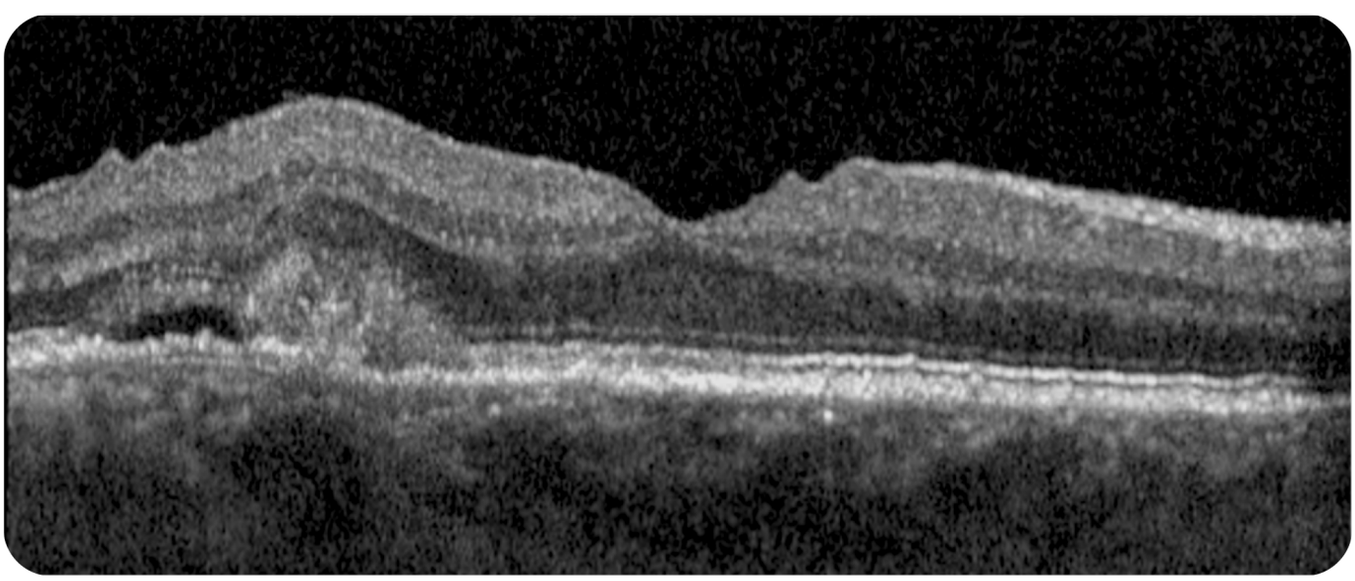
Age 84



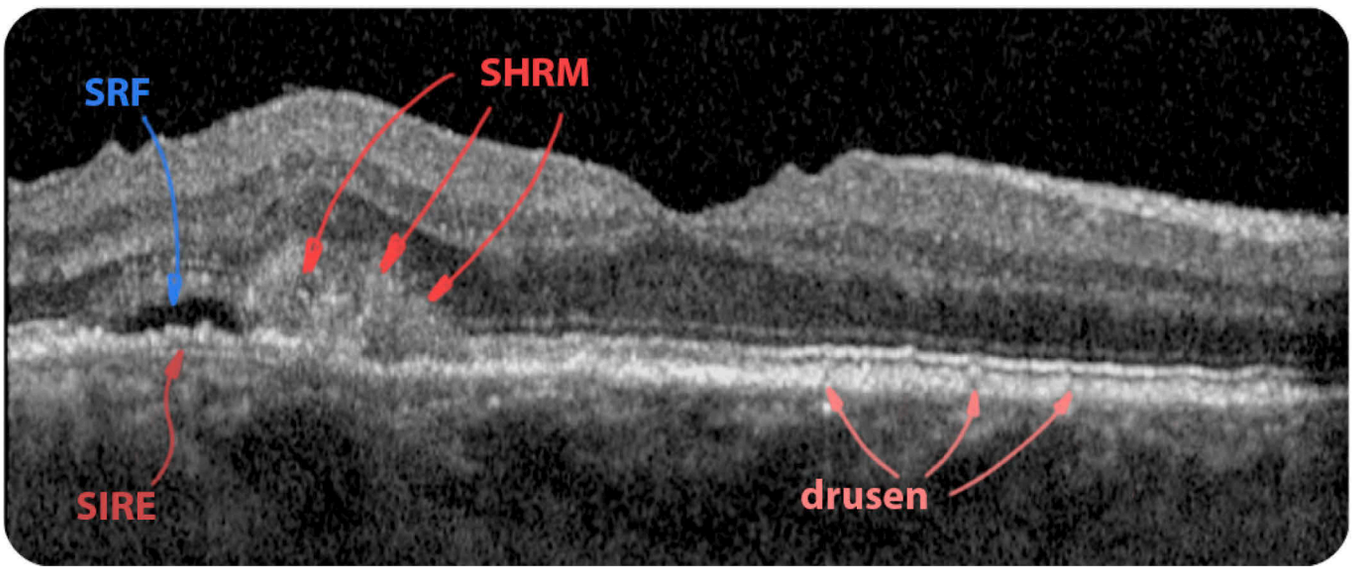
IR Image:
A hyporeflective area in the temporal macula.

Scan Quality:
Good without artifacts

Location:
Fovea



Case 14



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, Irregular
	Drusen	Druplets
	SIRE	With DLS and SRF
Subretinal	SHRM	Medium reflective (fuzzy) with associated SRF
	SRF	Exudation from MNV

Interpretation

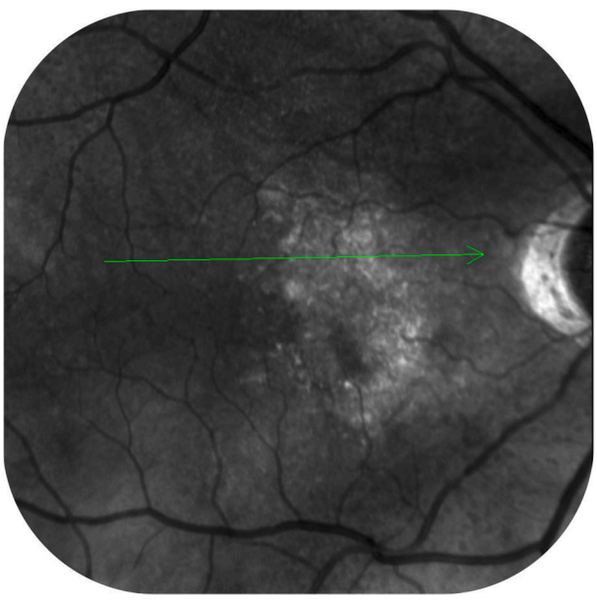
This eye's most striking feature is the pronounced accumulation of SHRM with associated SRF which is very consistent with a type 2 MNV. There is also a SIRE probably due to a type 1 MNV. Together these findings are very consistent with an **active mixed-type MNV**. There are multiple tiny druplets.

RPE: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **MNV**: Macular Neovascularization – **DLS**: Double-layer Sign

Case 15

Case 15

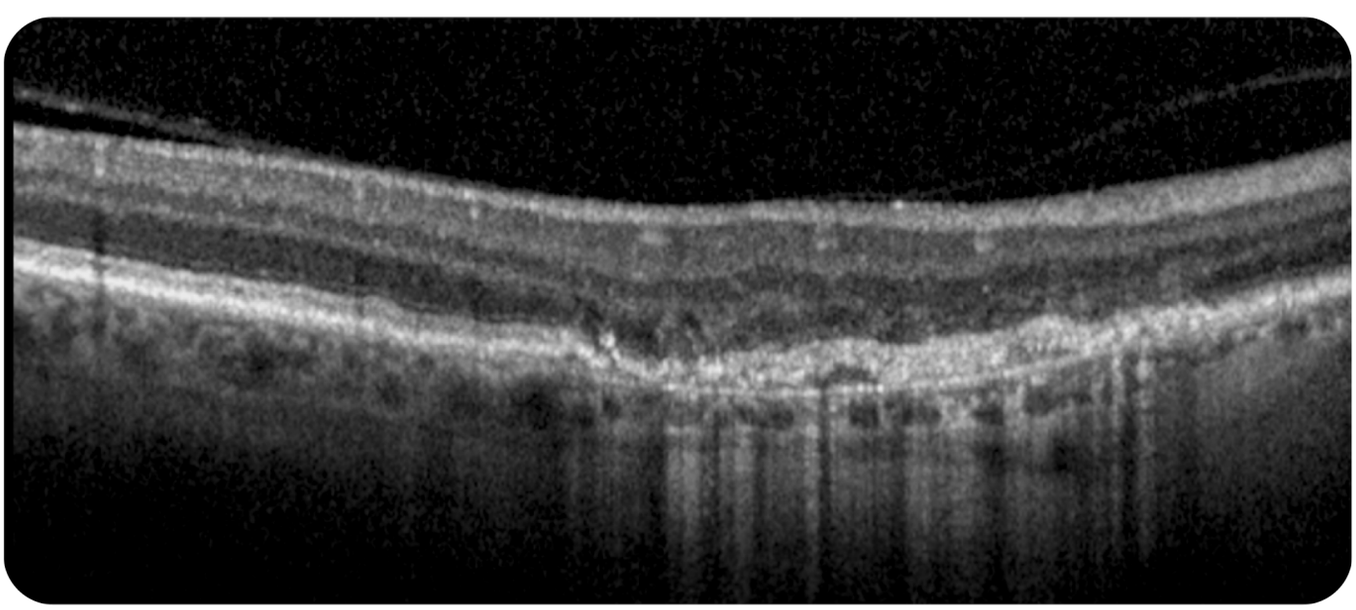
Age 88



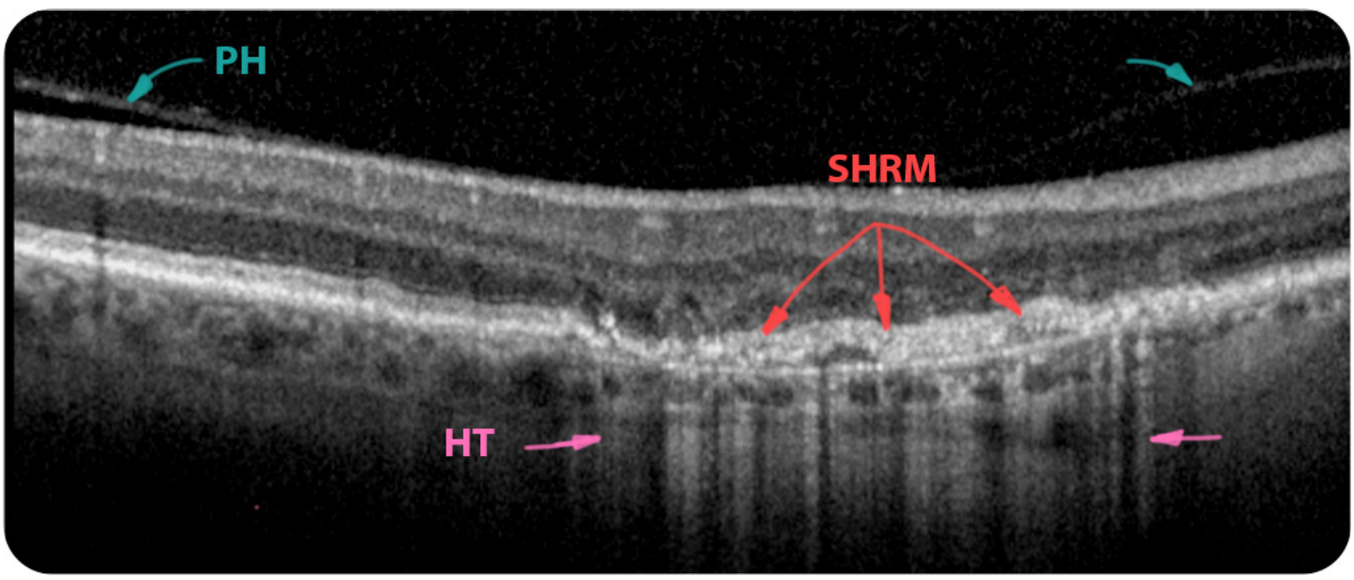
IR Image:
Dark image. An irregular hyperreflective area between the optic disc and the macula. Peripapillary chorioretinal atrophy.

Scan Quality:
Good with without artifacts

Location:
Parafovea



Case 15



Findings

Area	Alteration	Description
Sub-RPE	RPE	Atrophic
	Atrophy	RPE- atrophy with signal hypertransmission
Subretinal	SHRM	Hyperreflective (solid)
	PR	PR atrophy
Preretinal	PH	Posterior hyaloid

Interpretation

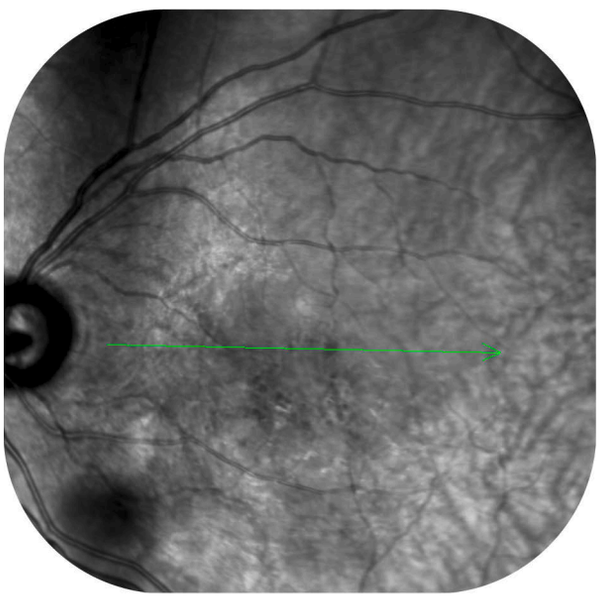
There is a large area of solid-looking SHRM, consistent with **fibrotic scar tissue**. The PR layer is thinned and the RPE seems to be atrophic with adjacent signal hypertransmission (HT). If one looks closely, the choroid is also thinned in the area of atrophy.

RPE: Retinal Pigment Epithelium – **SHRM**: Subretinal Hyperreflective Material – **PR**: Photoreceptor – **PH**: Posterior Hyaloid – **HT**: Hypertransmission

Case 16

Case 16

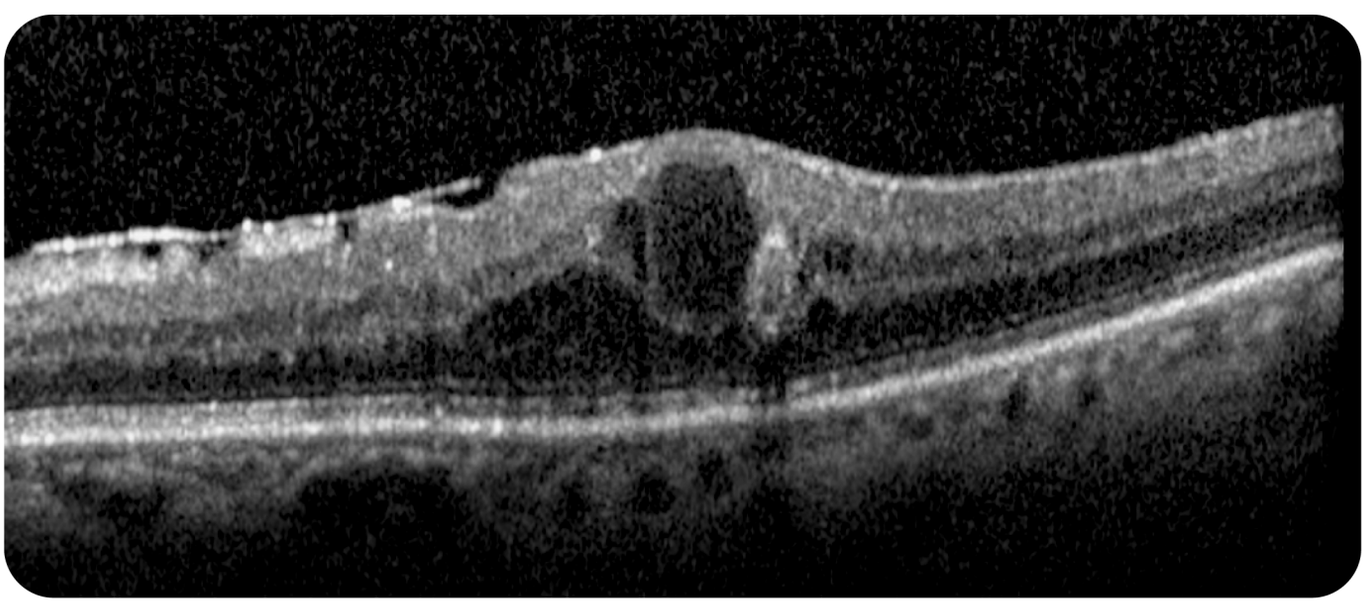
Age 60



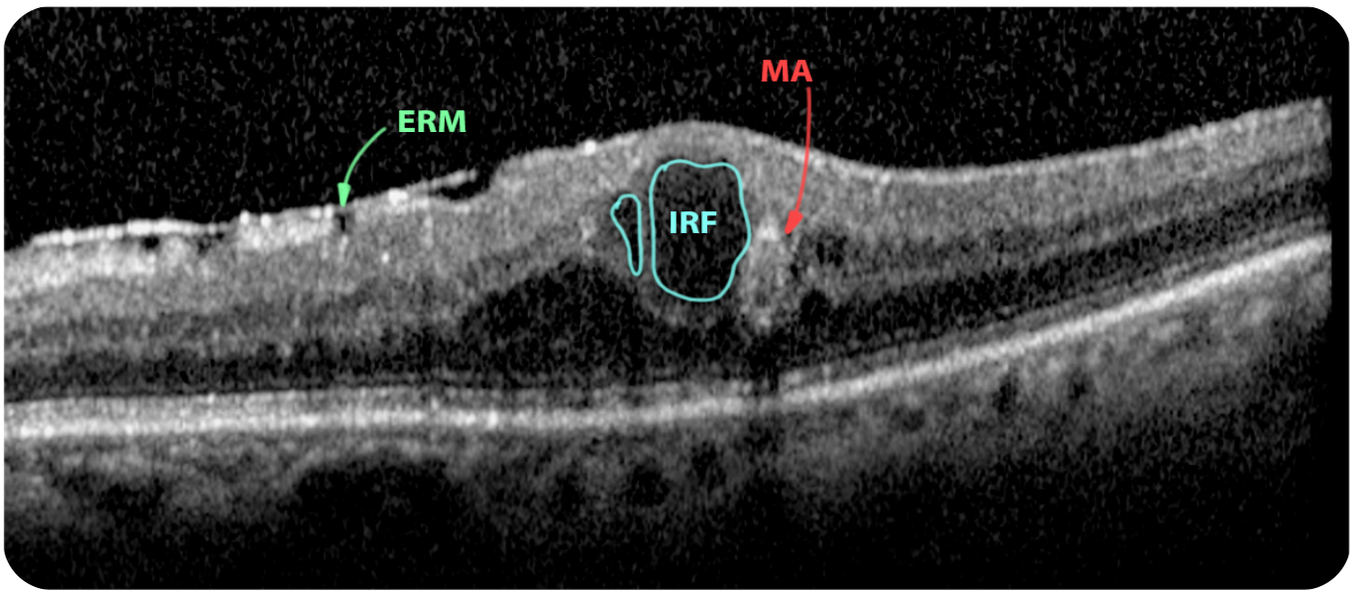
IR Image:
There are multiple black spots in the parafoveal region and a hyporeflective appearance of that area.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 16



Findings

Area	Alteration	Description
Intraretinal	IRF	Causing retinal thickening
	IHRM	Oval microaneurysm
Epiretinal	ERM	

Interpretation

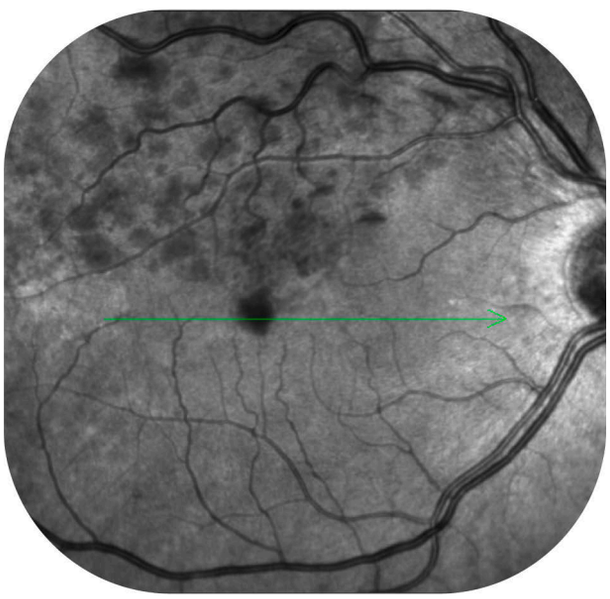
This eye's most striking feature is the large microaneurysm (MA), a hallmark of diabetic retinopathy, with associated IRF probably due to a leakage from the MA . This patient very likely has a **diabetic macular edema**. In addition, the ERM is causing a wrinkling of the RNFL.

IRF: Intraretinal Fluid – **IHRM**: Intraretinal Hyperreflective Material – **ERM**: Epiretinal Membrane – **MA:** Microaneurysm – **RNFL:** Retinal Nerve Fiber Layer

Case 17

Case 17

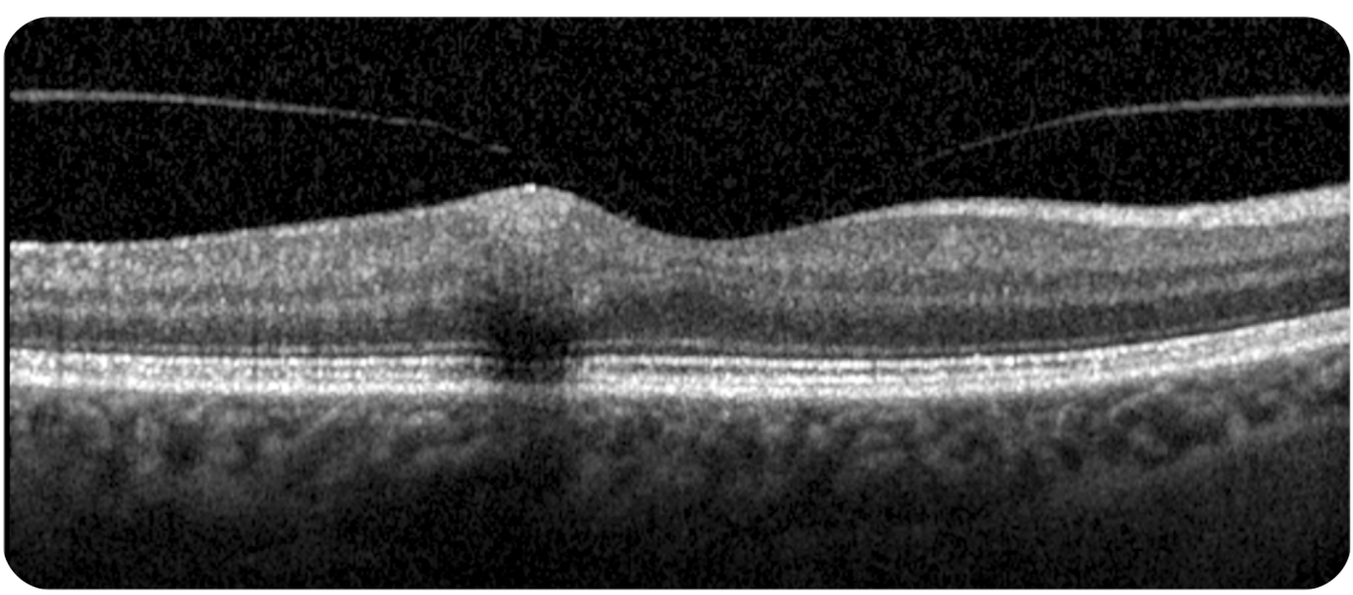
Age 57



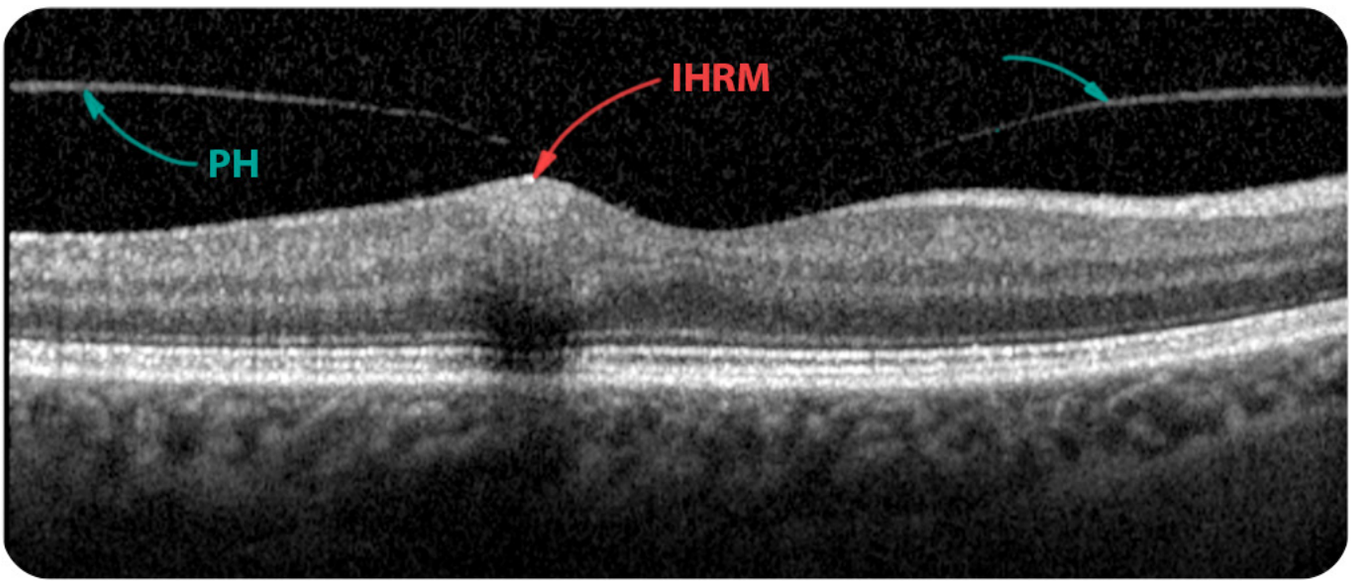
IR Image:
The superior temporal veins appear tortuous. Additionally, blot and flame-shaped retinal hemorrhages are visible in the superior macular pole.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 17



Findings

Area	Alteration	Description
Intraretinal	IHRM	intraretinal haemorrhage
Preretinal	VMA	Vitreomacular adhesion

Interpretation

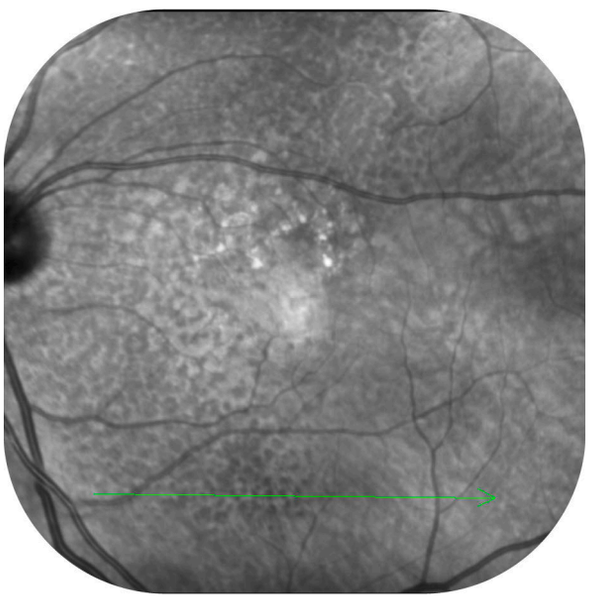
The most striking feature of this scan is the accumulation of IHRM with adjacent signal blockage – a finding very consistent with an intraretinal hemorrhage. Looking at the IR image, the IHRM correlates with the black spot in the image – giving us confidence in our interpretation; The IR image provides a picture consistent with a **BRVO**.

IHRM: Intraretinal Hyperreflective Material – **VMA**: Vitreomacular Adhesion – **BRVO**: Branch Retinal Vein Occlusion – **PH:** Posterior Hyaloid

Case 18

Case 18

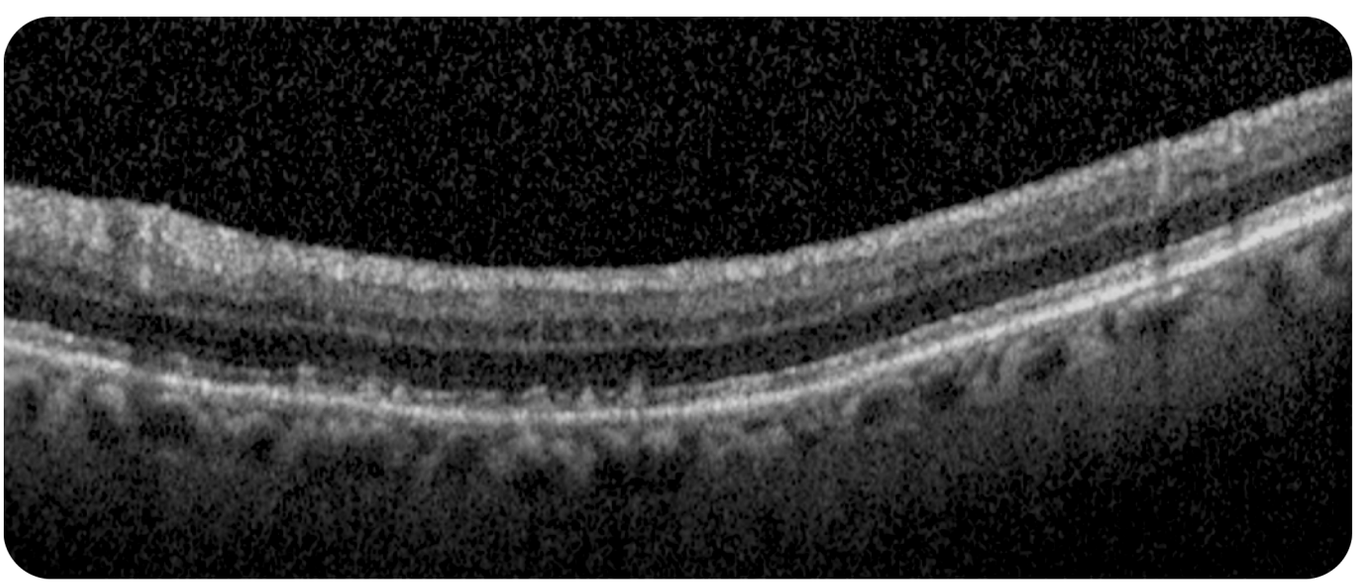
Age 82



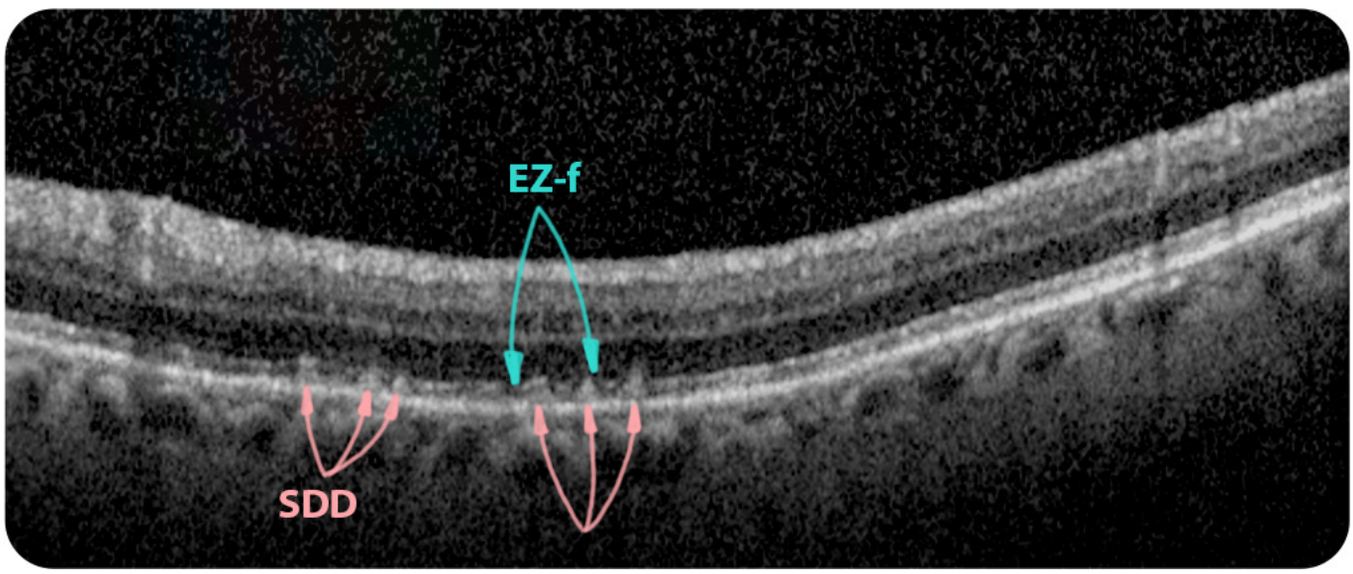
IR Image:
There are multiple hyperreflective spots as well as disseminated reticular pseudodrusen. However, the fovea seems to be spared.

Scan Quality:
Good with no artifacts

Location:
Peripheral macula



Case 18



Findings

Area	Alteration	Description
Subretinal	SDD	Reticular pseudodrusen
	PR	EZ fragmented

Interpretation

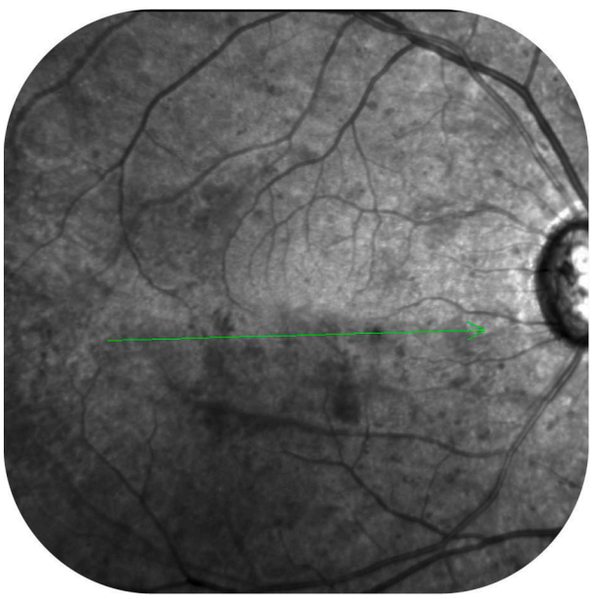
In this scan, we can appreciate well-delineated reticular pseudodrusen that caused EZ fragmentation. We are looking at a patient with **AMD**.

AMD: Age-related Macular Degeneration – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptor - **EZ-f**: Ellipsoid Zone Fragmentation

Case 19

Case 19

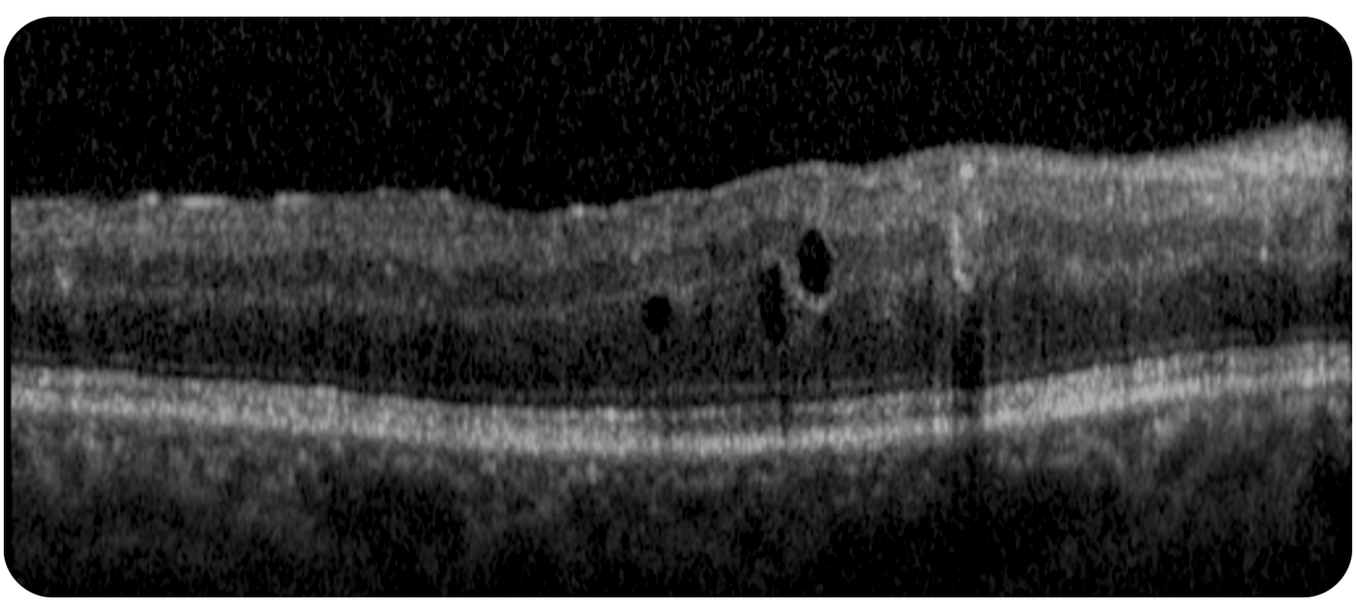
Age 57



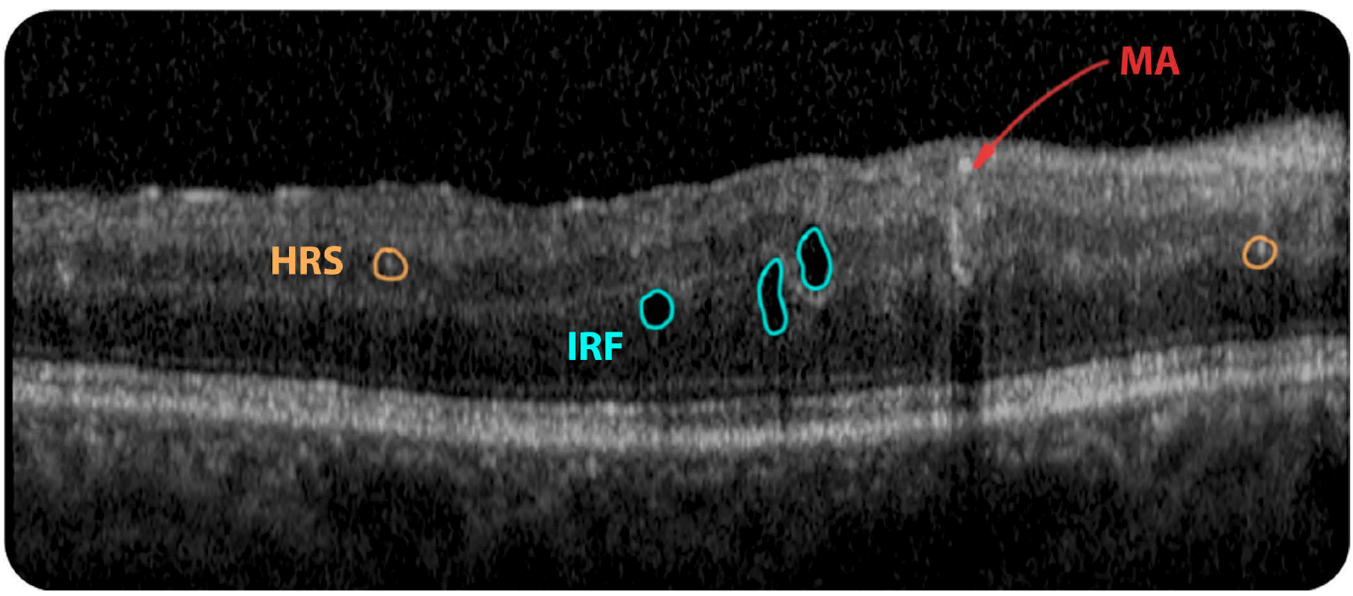
IR Image:
There are disseminated hyporeflective spots that could represent retinal hemorrhages and microaneurysms. The inferior half of the fundus also has a hyporeflective appearance.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 19



Findings

Area	Alteration	Description
Intraretinal	IRF	Minimal thickening
	IHRM	Oval microaneurysm
	HRS	Outer retina

Interpretation

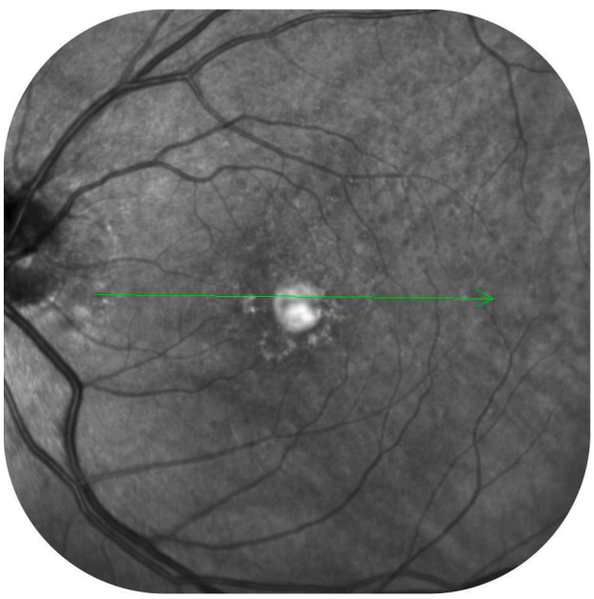
This eye's most striking feature is the large, oval microaneurysm, a hallmark of diabetic retinopathy. In addition, three fluid-filled spaces formed around the OPL, probably due to increased vascular permeability. They are causing a minimal thickening of the retina and, thus, early-stage **diabetic macular edema**.

IRF: Intraretinal Fluid – **IHRM**: Intraretinal Hyperreflective Material – **HRS**: Hyperreflective Spots – **OPL**: Outer Plexiform Layer

Case 20

Case 20

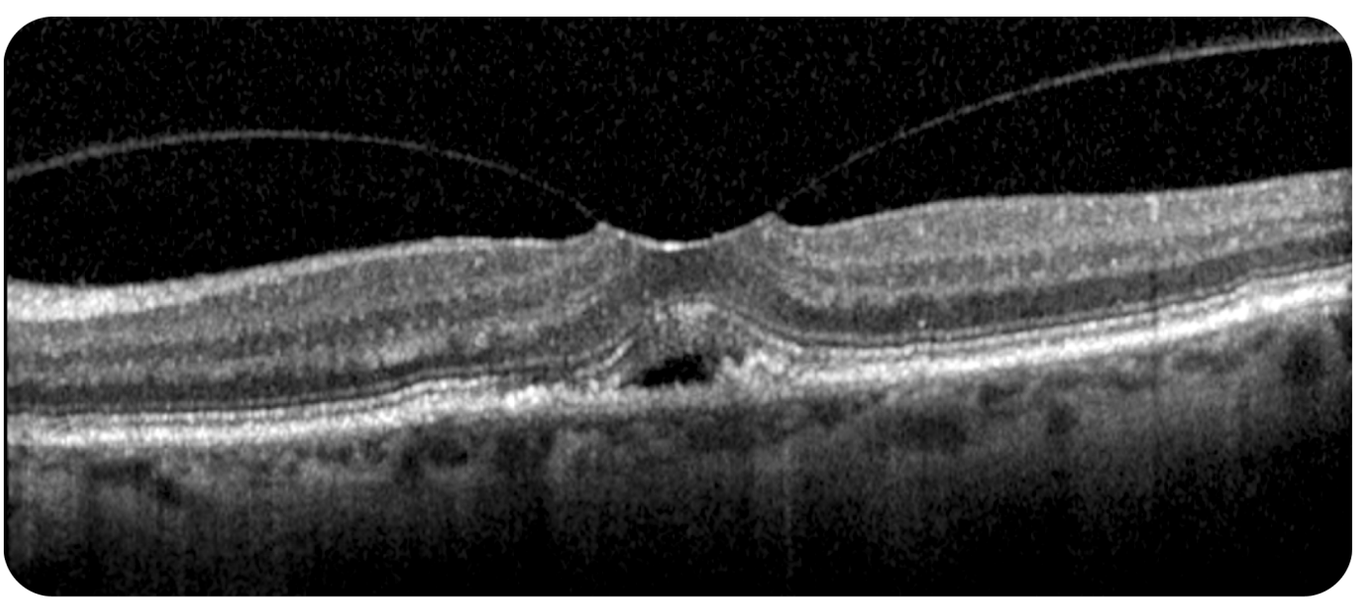
Age 53



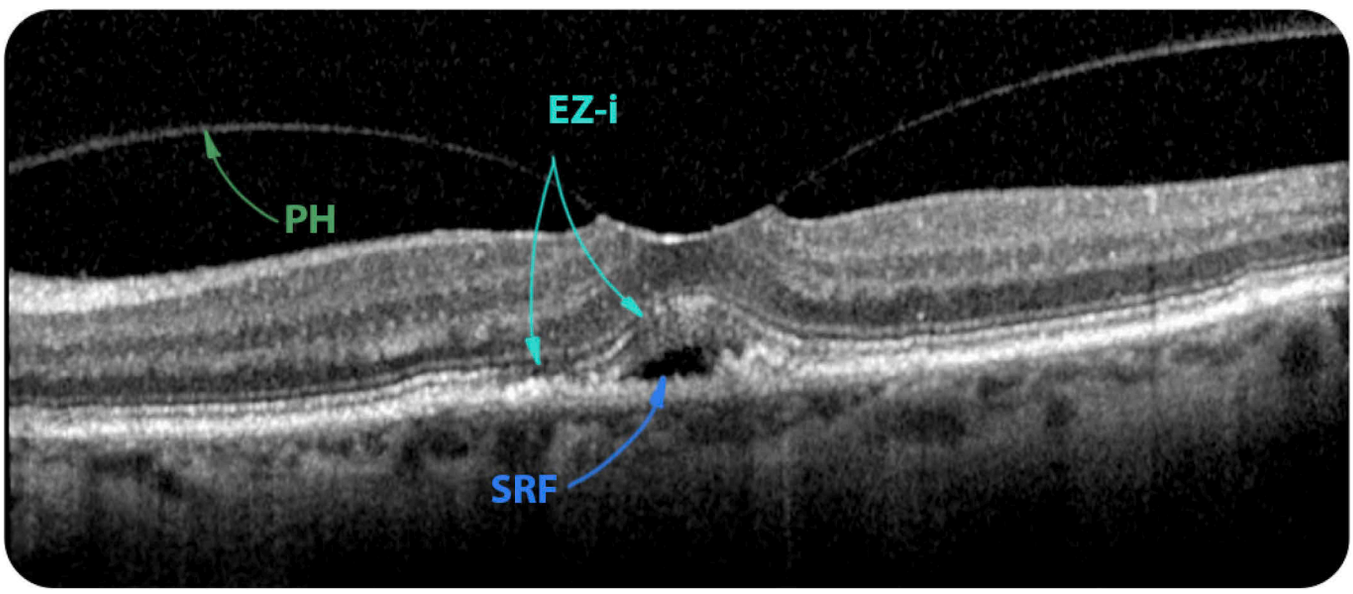
IR Image:
Central light reflex artifact and a few disseminated drusen around the macula.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 20



Findings

Area	Alteration	Description
Subretinal	SRF	Tractional
	EZ	EZ interrupted
Preretinal	VMT	Causing neurosensory detachment

Interpretation

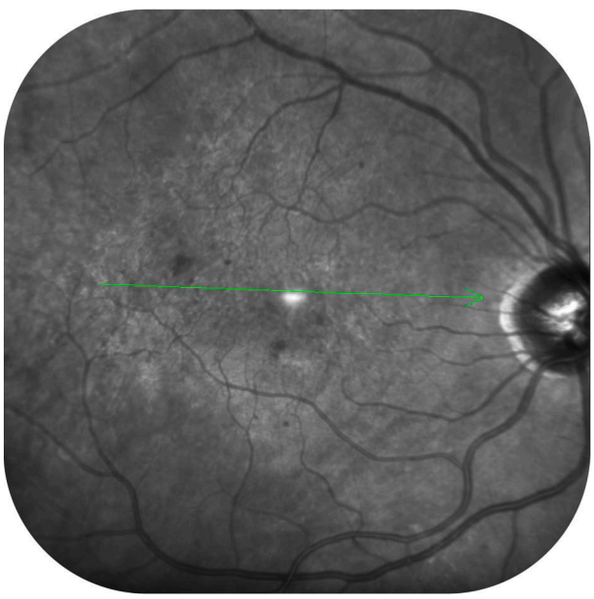
The most striking feature of this eye is a **vitreomacular traction** that is causing a detachment of the retina from the RPE leading to an accumulation of SRF. Additionally, the EZ appears irregular at the foveola, and it is also interrupted.

SRF: Subretinal Fluid – **EZ-i**: Ellipsoid Zone Interruption – **VMT**: Vitreomacular Traction – **RPE**: Retinal Pigment Epithelium – **PH:** Posterior Hyaloid

Case 21

Case 21

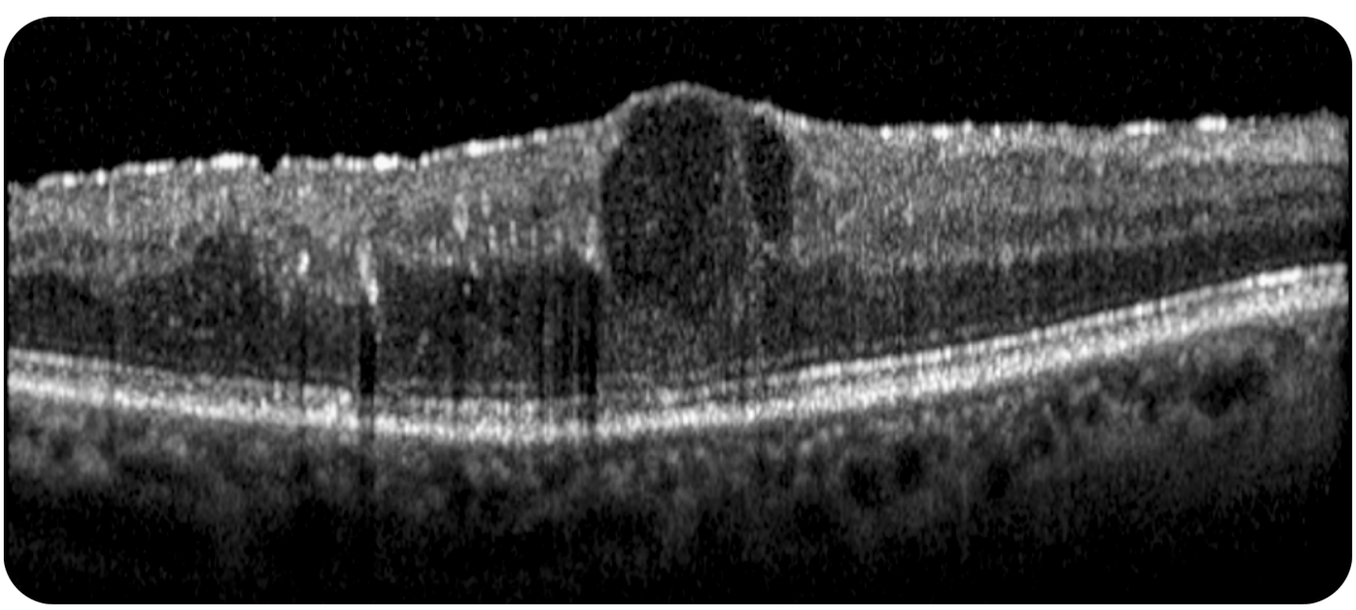
Age 52



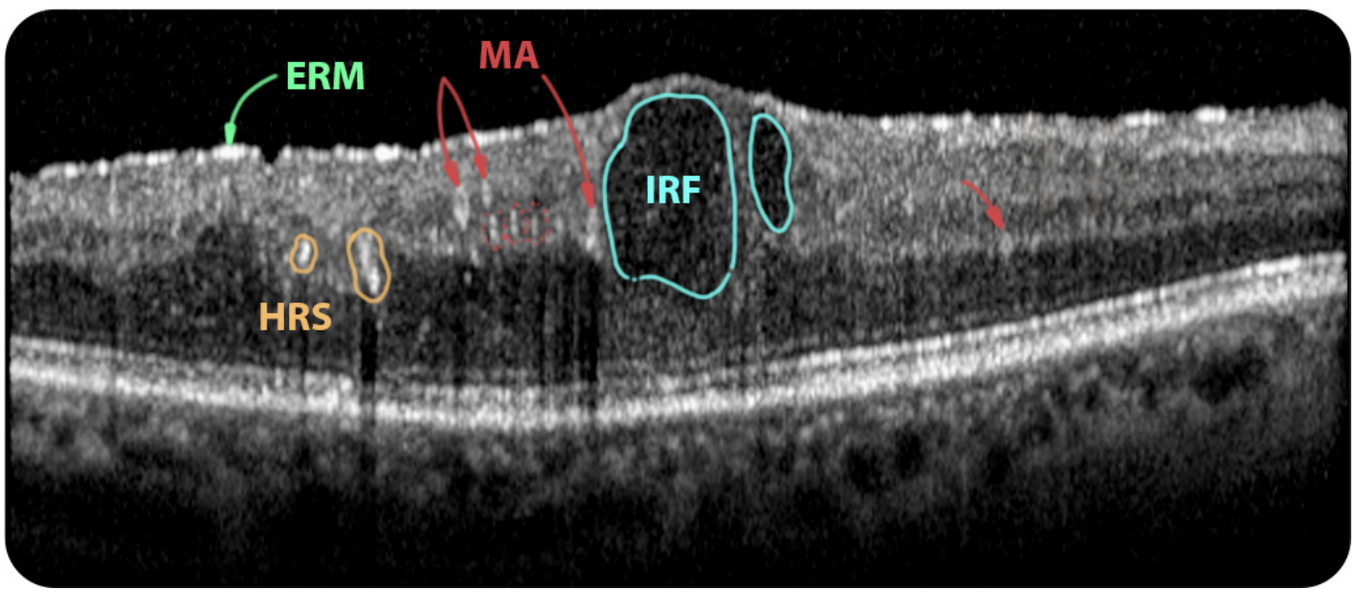
IR Image:
Multiple dark spots around the macula, fovea looks slightly darker. Light reflex artifact in the center.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 21



Findings

Area	Alteration	Description
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudate
	IHRM	Microaneurysm
Epiretinal	ERM	Thin

Interpretation

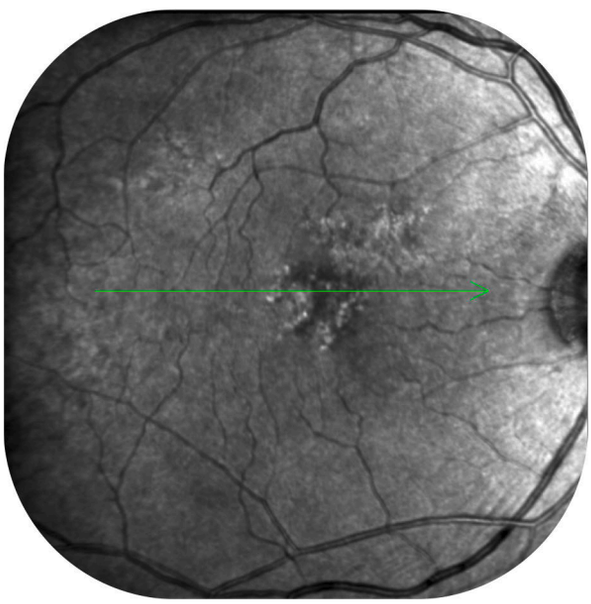
There are multiple microaneurysms and hard exudates – both are hallmarks of DR. The accumulation of IRF causes retinal thickening and leads to the suspected diagnosis of a **diabetic macular edema**. Additionally, there is a distinct ERM.

IRF: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **IHRM**: Intraretinal Hyperreflective Material – **ERM**: Epiretinal Membrane – **DR**: Diabetic Retinopathy – **MA:** Microaneurysms

Case 22

Case 22

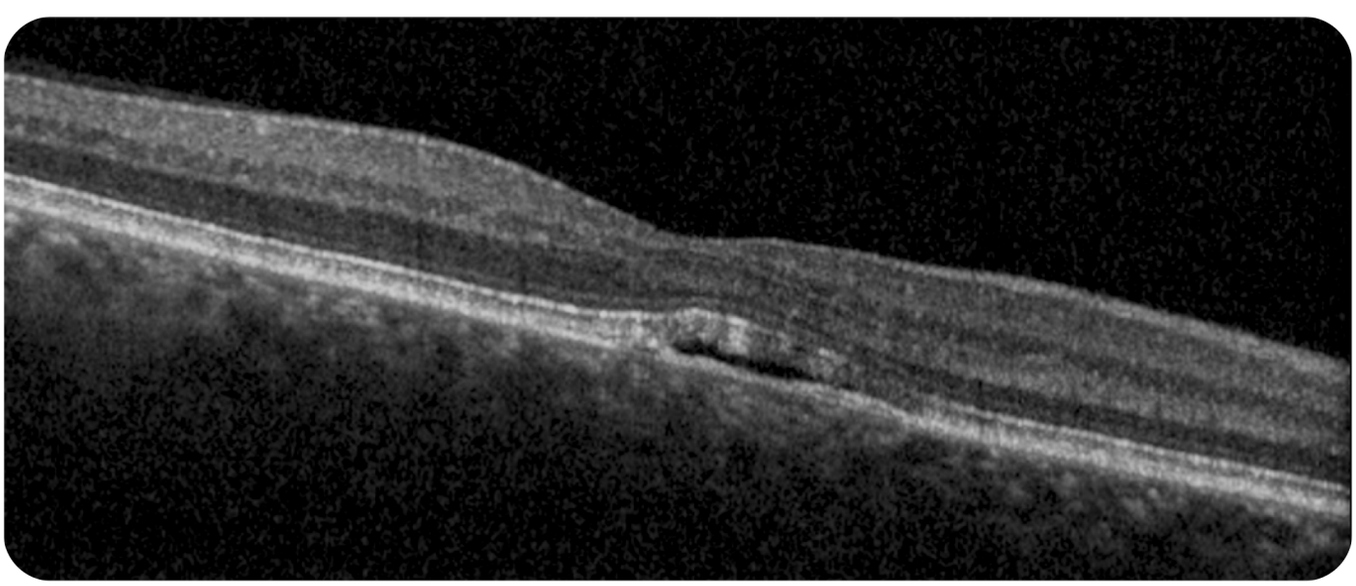
Age 60



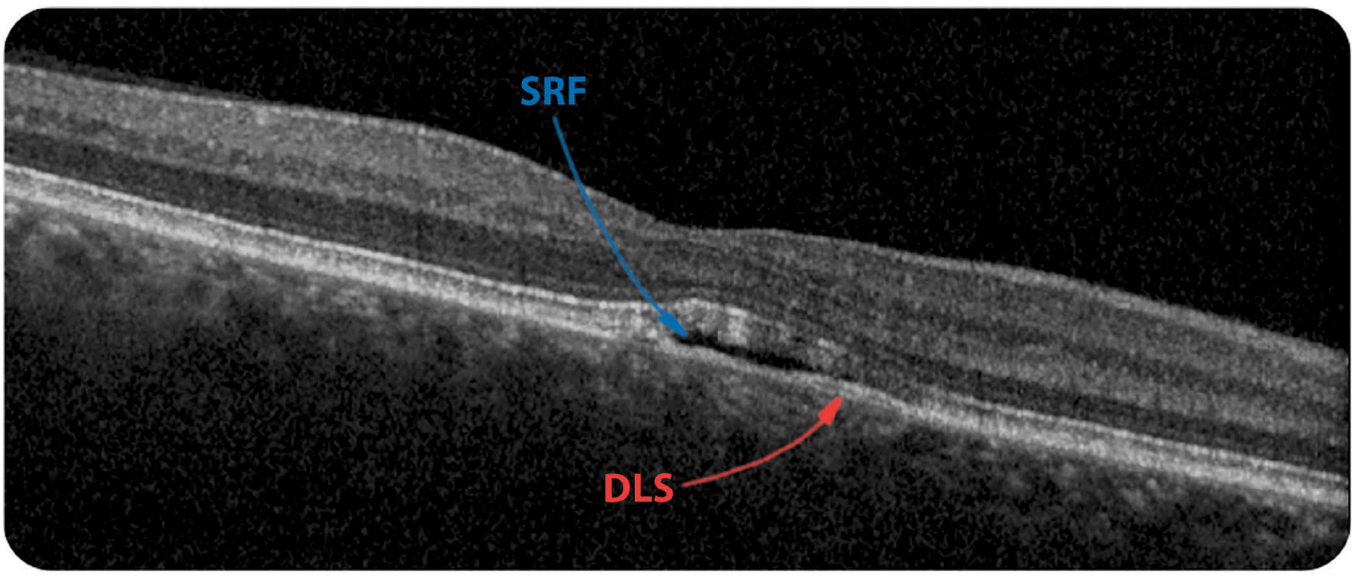
IR Image:
The fovea appears hyporeflective, and there are multiple hyperreflective spots.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 22



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	SIRE	With DLS and SRF
Subretinal	SRF	Associated to RPE alteration

Interpretation

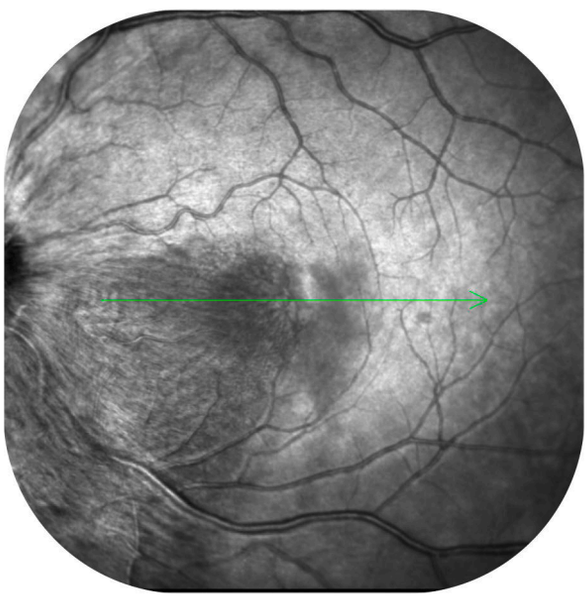
There is a very shallow elevation of the RPE (SIRE) with an evident DLS and associated SRF. This PED possibly contains an MNV that exudates into the subretinal space – findings suspicious of an **active type 1 MNV** or **CSC** as there are no drusen or other sign of degeneration and the choroid is not fully visible in this scan. Further diagnostics are needed.

RPE: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **SRF**: Subretinal Fluid – **DLS**: Double-layer Sign – **PED**: Pigment Epithelial Detachment – **MNV**: Macular Neovascularization

Case 23

Case 23

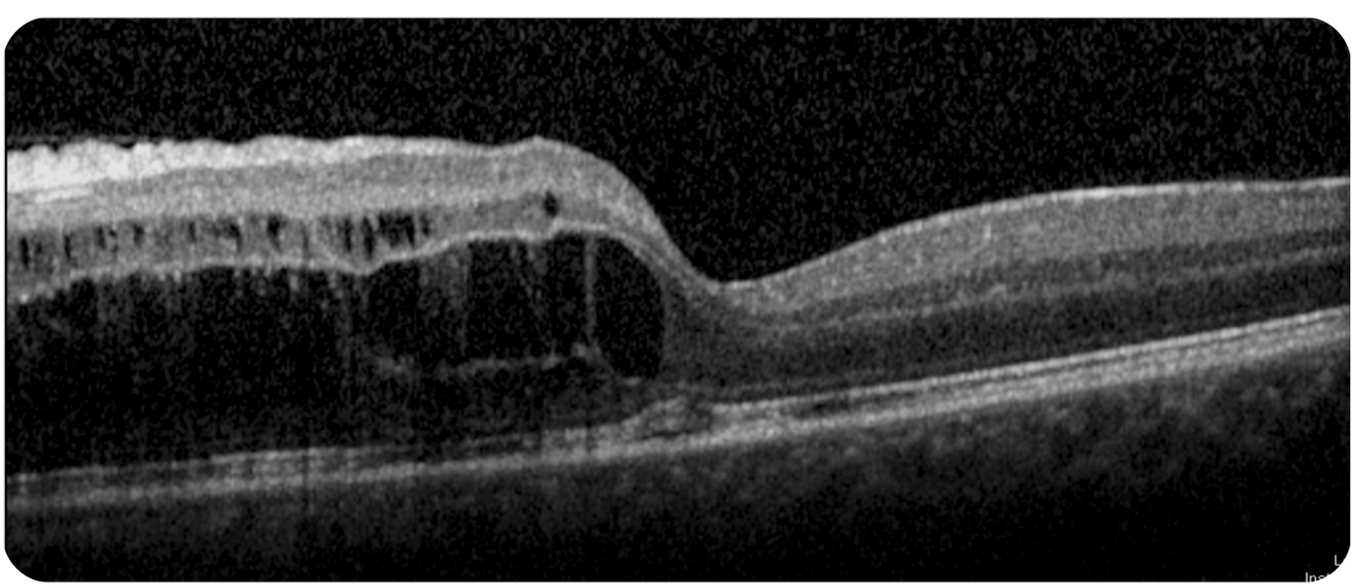
Age 66



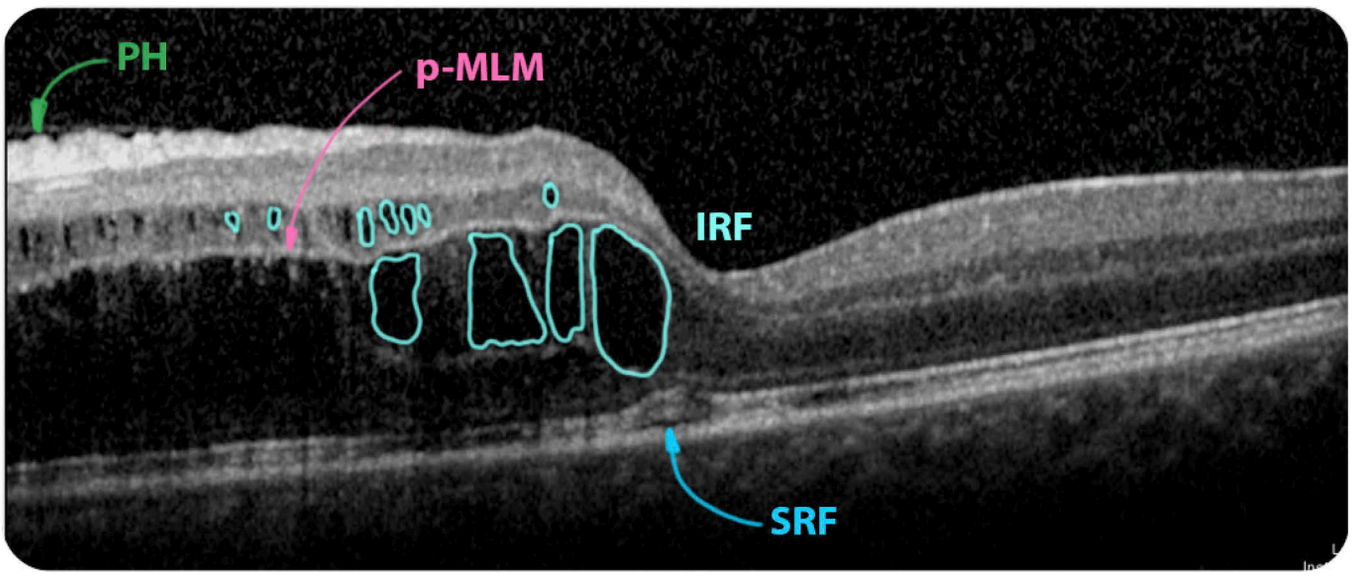
IR Image:
The left inferior quadrant of the macula appears hyporeflective with dilated veins. An even darker area surrounds the central fovea.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 23



Findings

Area	Alteration	Description
Subretinal	SRF	Associated with CME
Intraretinal	IRF	Causing retinal thickening
	IRL	Hyperreflective, p-MLM
Preretinal	PH	Posterior hyaloid

Interpretation

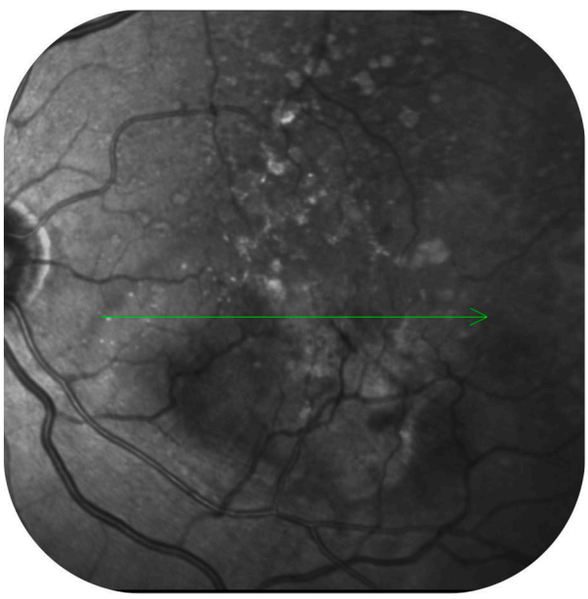
This patient is suffering from a **CME** with minimal SRF accumulation. The hyperreflective appearance of the inner retinal layers with a p-MLM indicate retinal ischemia, secondary to artery flow impairment. The IR image in conjunction with the OCT scan, present a picture consistent with **active CME secondary to a BRVO with artery flow impairment**.

SRF: Subretinal Fluid – **IRF**: Intraretinal Fluid – **IRL**: Inner Retinal Layers – **PH**: Posterior Hyaloid – **CME**: Cystoid Macular Edema – **p-MLM**: Prominent Middle Limiting Membrane – **BRVO**: Branch Retinal Vein Occlusion

Case 24

Case 24

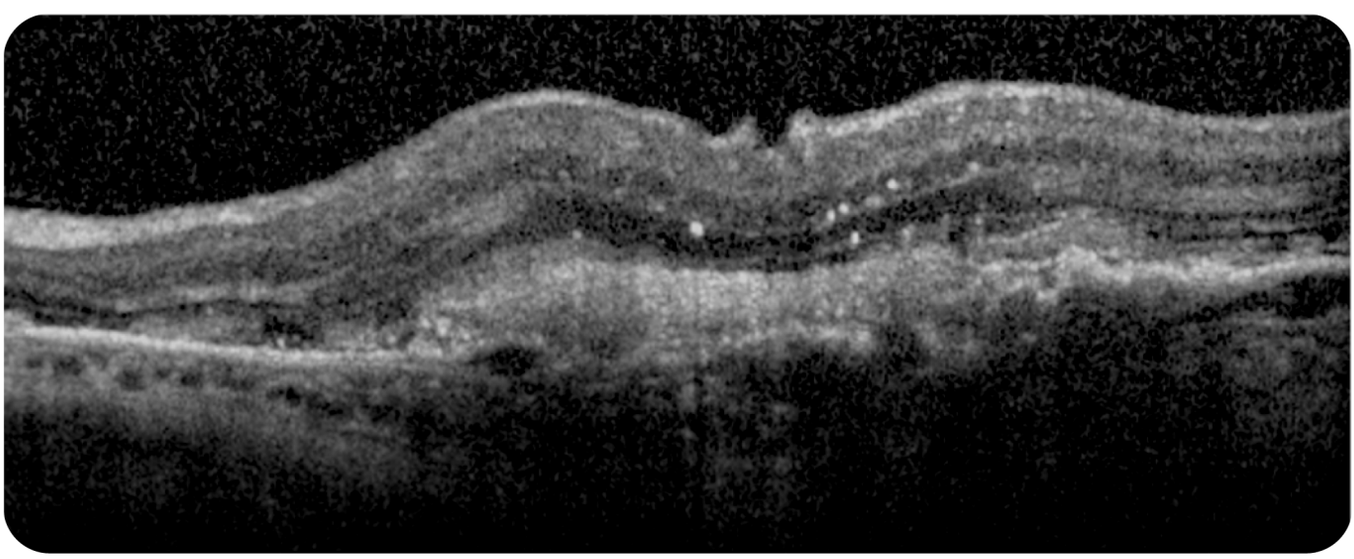
Age 89



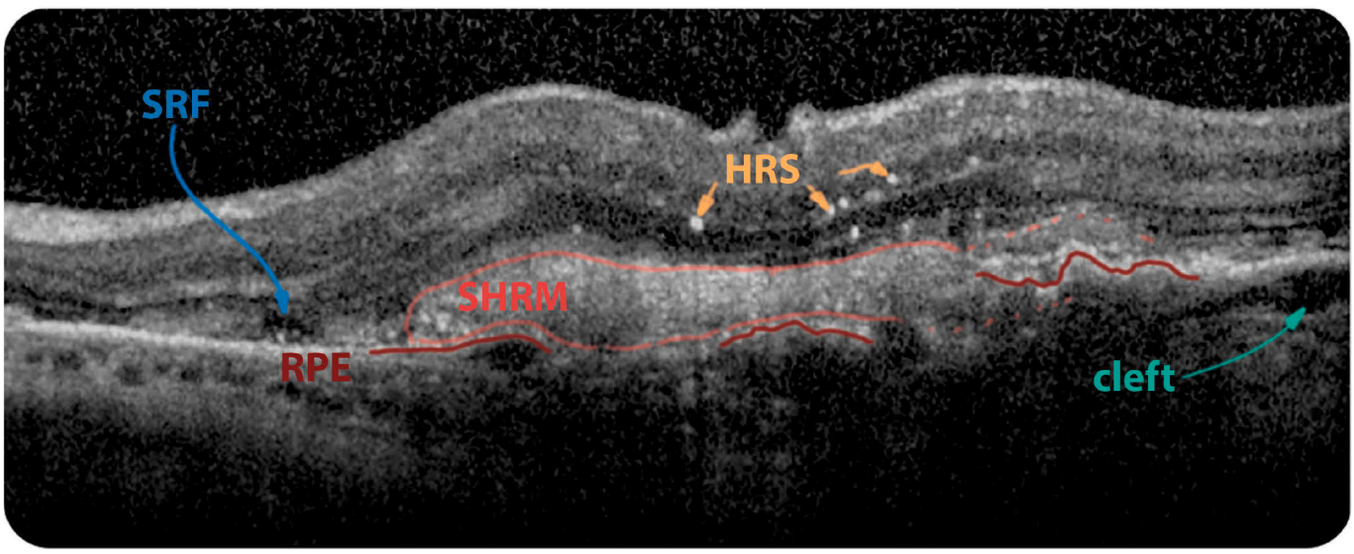
IR Image:
There are multiple hyperreflective areas in the superior half of the image – consistent with drusen or areas of atrophy; the inferior portion of the image presents a large hyporeflective area, consistent with fluid accumulation.

Scan Quality:
Good with no artifacts

Location:
Parafoveal macula



Case 24



Findings

Area	Alteration	Description
Sub-RPE	Choroid	Prechoroidal cleft
	RPE	Interrupted, elevated
	PED	Heterogenous RPE elevation
Subretinal	SHRM	Moderately hyperreflective
	PR	PR atrophy
	SRF	Minimal (suspect)
Intraretinal	HRS	Inner and outer retina

Interpretation

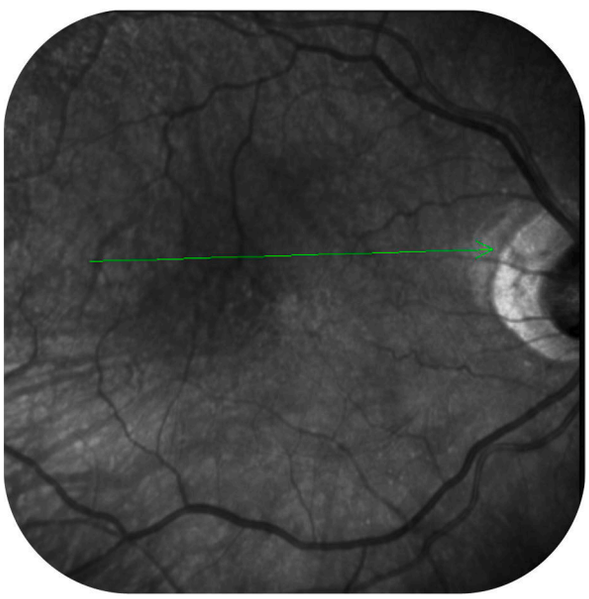
The most striking feature of this scan is the large area of SHRM, which could represent a mature MNV (fibrotic/fibrovascular material). There is PR atrophy above the SHRM and on the left side is an SRF-suspect region which should be further investigated. We are looking at a patient with suspected **MNV, secondary to AMD** (drusen suspect areas in the IR image). In this scan, the HRS could represent degenerated retinal tissue or lipid exudates. There is also a prechoroidal cleft temporally, which is more common in anti-VEGF treated eyes.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **SHRM**: Subretinal Hyperreflective Material – **PR**: Photoreceptor – **SRF**: Subretinal Fluid – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization

Case 25

Case 25

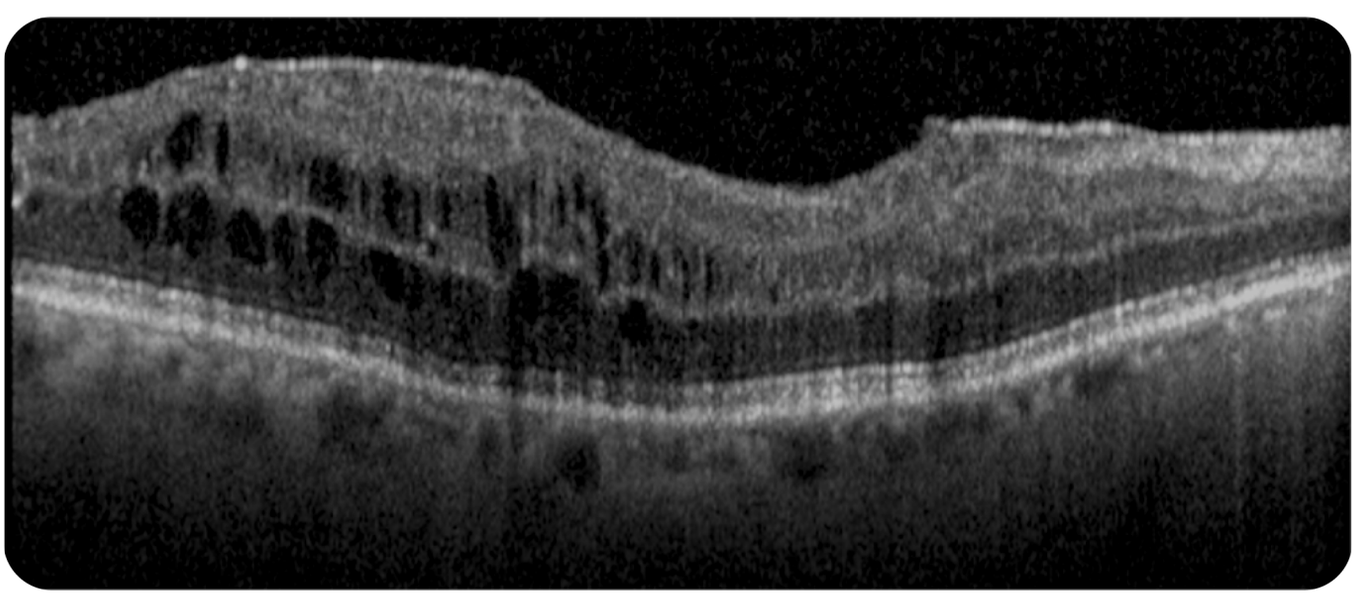
Age 55



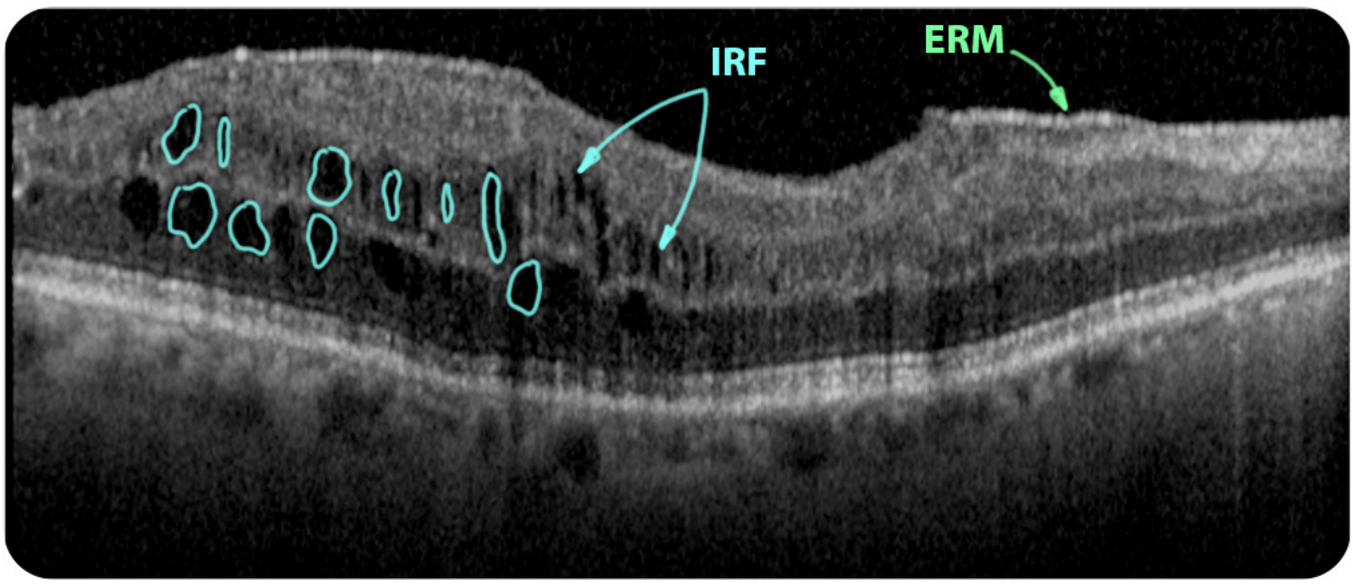
IR Image:
Overall dark image with an even darker appearance of the perifovea. Peripapillary chorioretinal atrophy.

Scan Quality:
Good with no artifacts

Location:
Parafoveal



Case 25



Findings

Area	Alteration	Description
Intraretinal	IRF	Widespread
Epiretinal	ERM	Thin

Interpretation

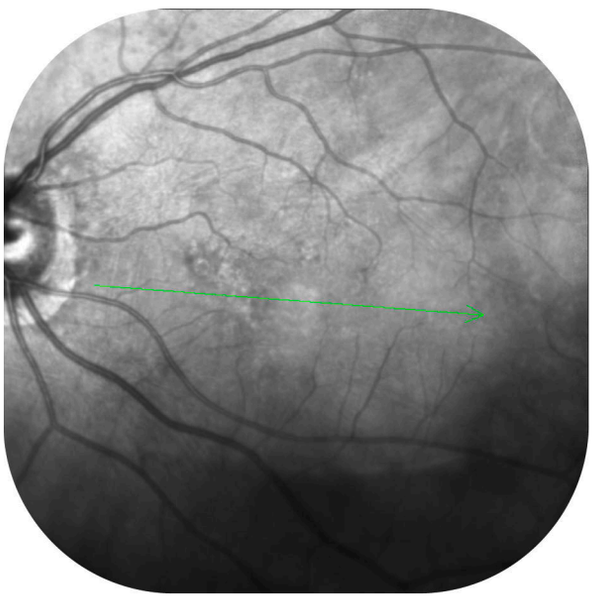
This patient has a thin ERM. There is widespread accumulation of IRF, causing a **CME**, but there is no clear indication of the origin of the CME.

IRF: Intraretinal Fluid – **CME**: Cystoid Macular Edema – **ERM**: Epiretinal Membrane

Case 26

Case 26

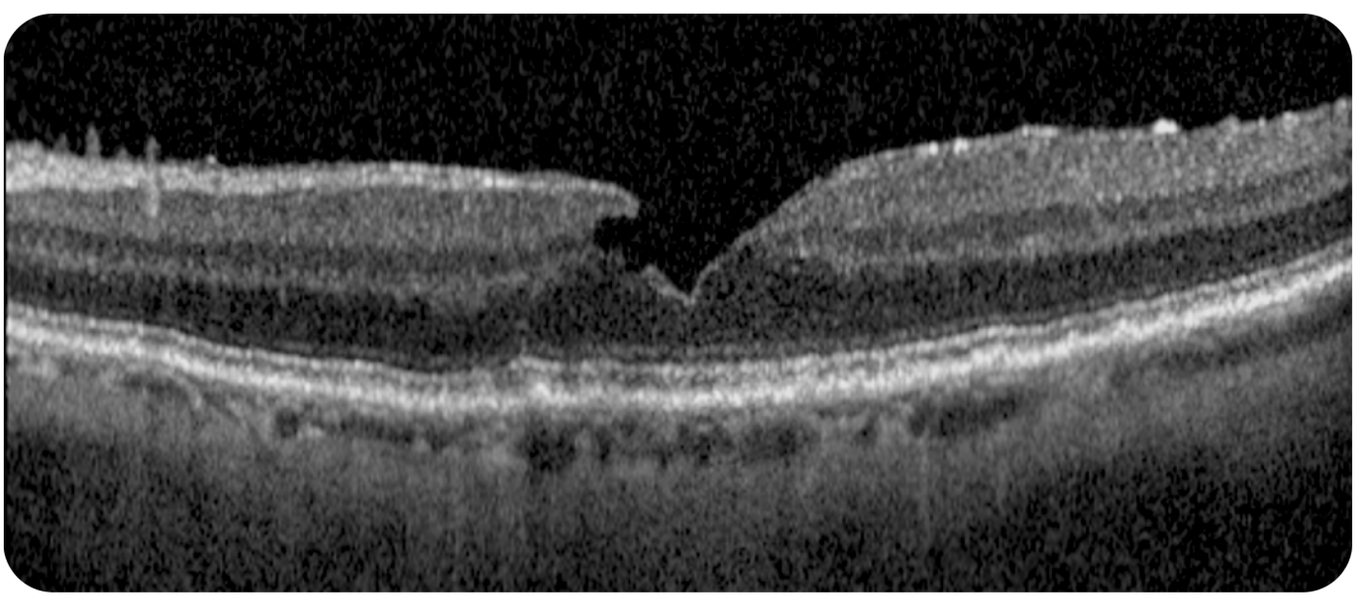
Age 63



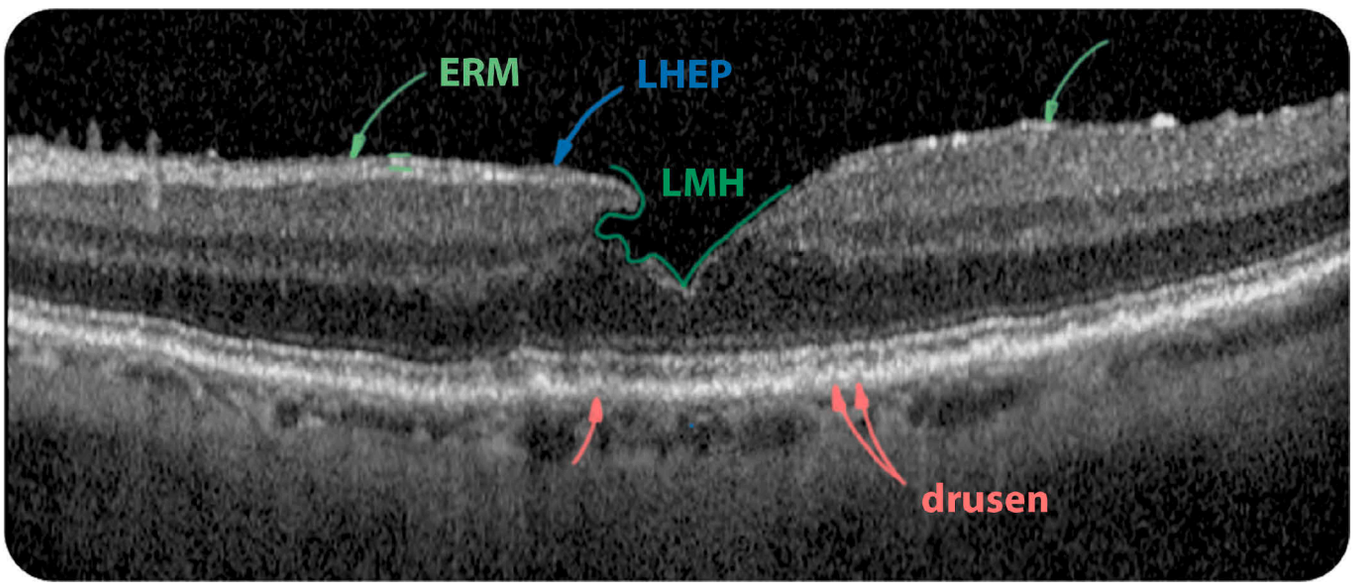
IR Image:
Superior-temporal to the fovea, there is an area with a wrinkled appearance.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 26



Findings

Area	Alteration	Description
Sub-RPE	RPE	Irregular
	Drusen	Multiple micro drusen
Epiretinal	ERM	Thin
Preretinal	LMH	With LHEP

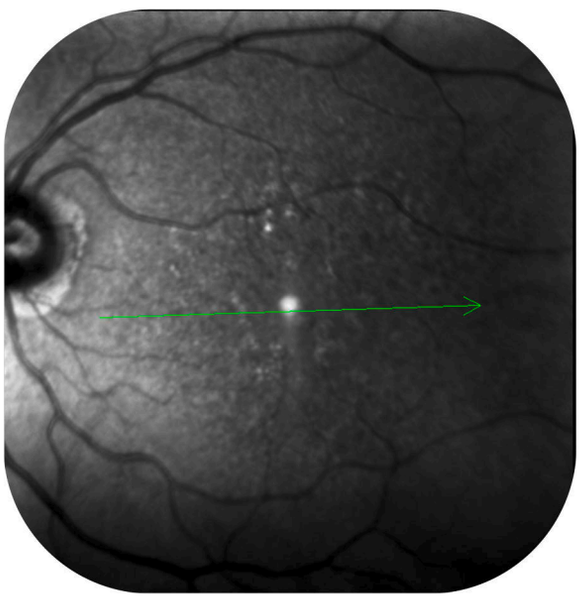
Interpretation

In this eye the foveal contour is interrupted, leaving **a lamellar macular hole** with associated LHEP. The RPE also has an irregular appearance with the presence of multiple micro-drusen. Additionally, one can find a thin ERM.

RPE: Retinal Pigment Epithelium – **ERM**: Epiretinal Membrane – **LMH**: Lamellar Macular Hole – **LHEP**: Lamellar Hole Associated Epiretinal Proliferation

Case 27

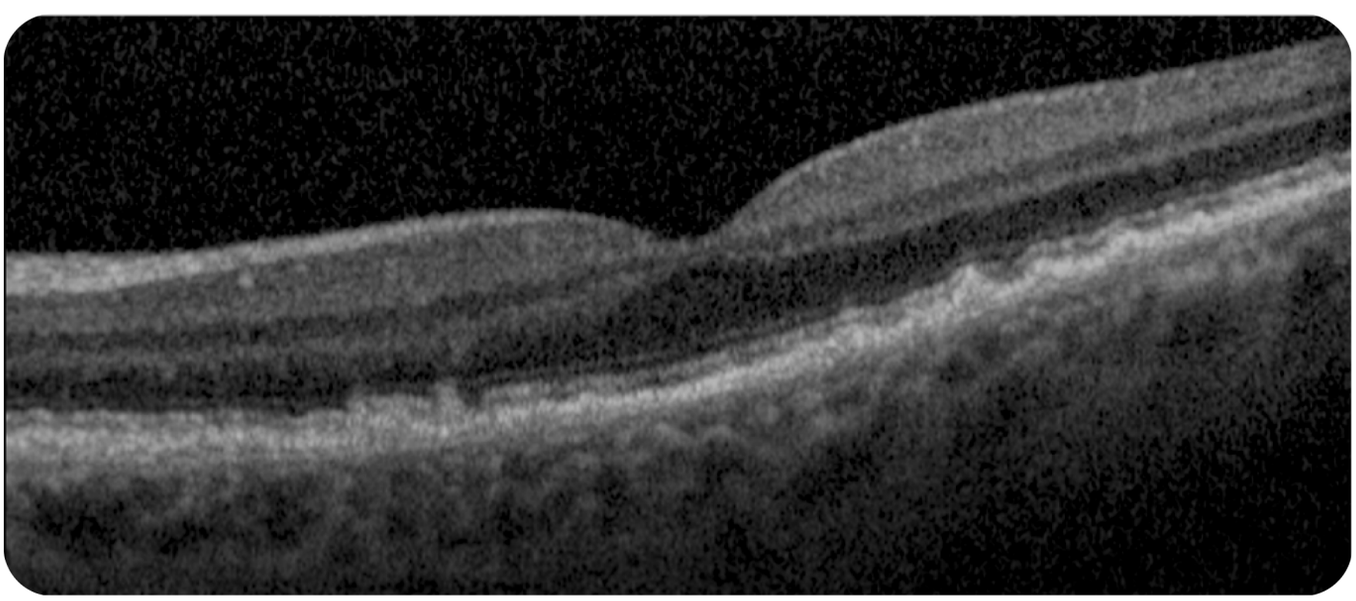
Age 84



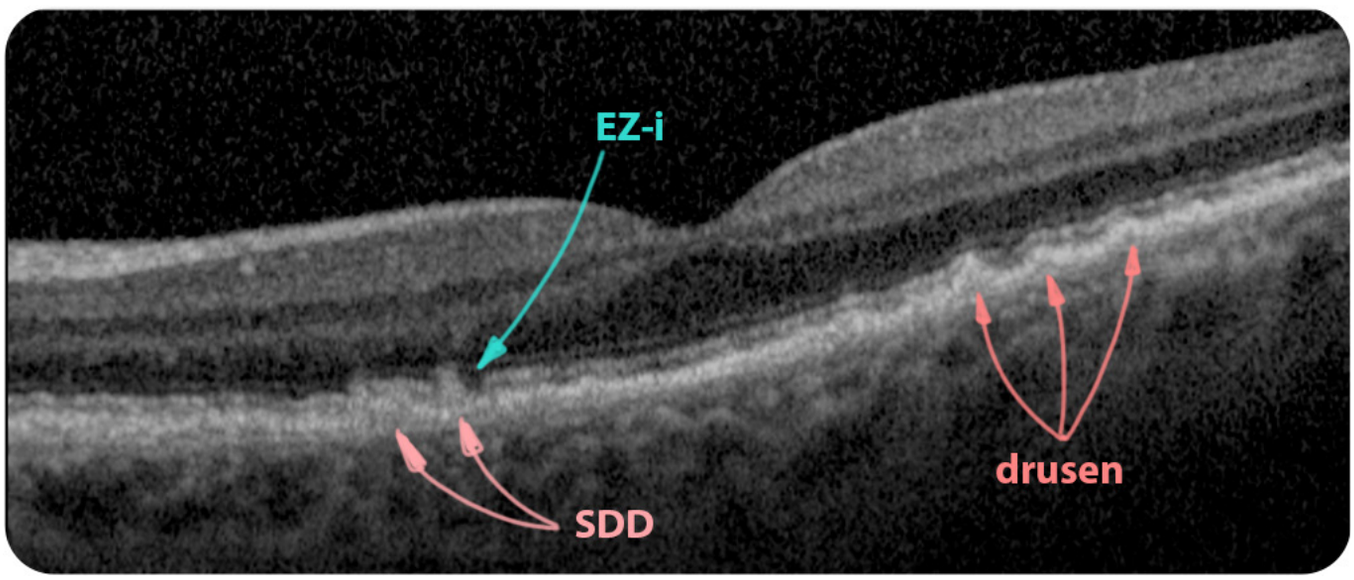
IR Image:
The IR image is dark, out of focus, and contains a central light artifact. However, it does reveal areas suspicious of drusen surrounding the macula.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 27



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple, small
Subretinal	SDD	Reticular pseudodrusen
	PR	EZ interrupted

Interpretation

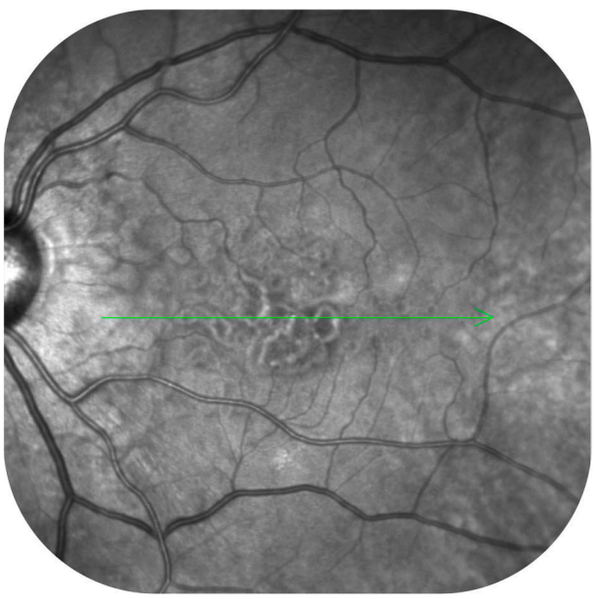
This patient has multiple small drusen and SDD scattered parafoveally. In addition, the EZ is interrupted by a larger SDD. These findings are consistent with **AMD**.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptor – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption

Case 28

Case 28

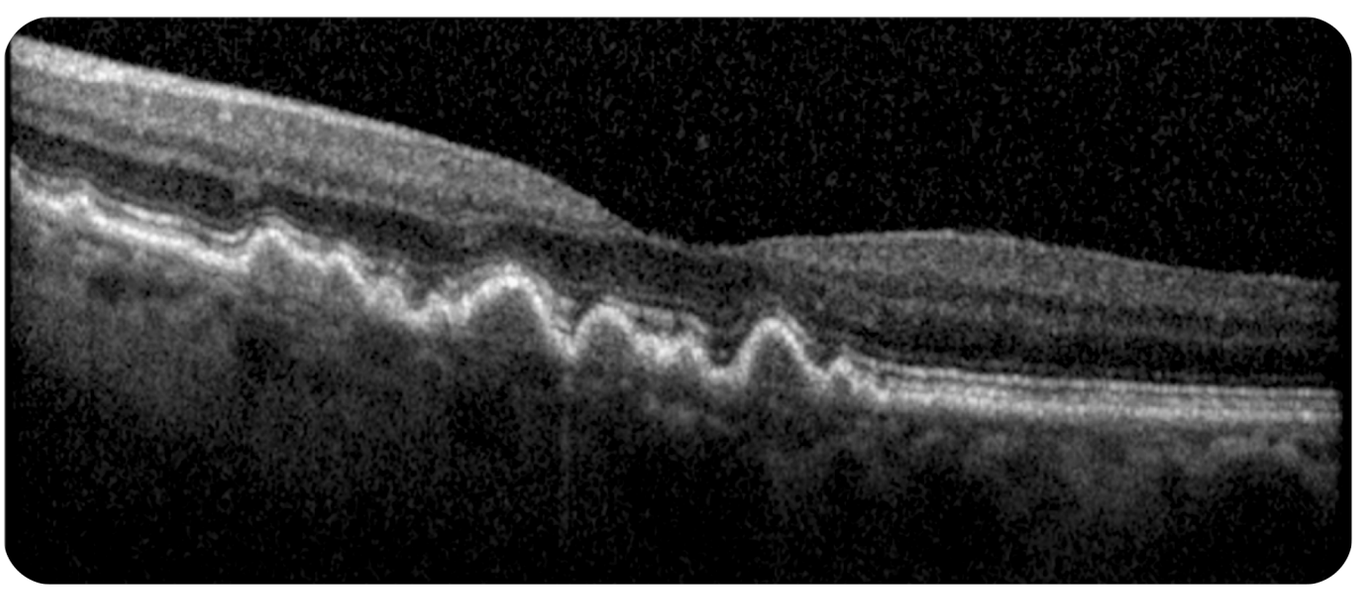
Age 76



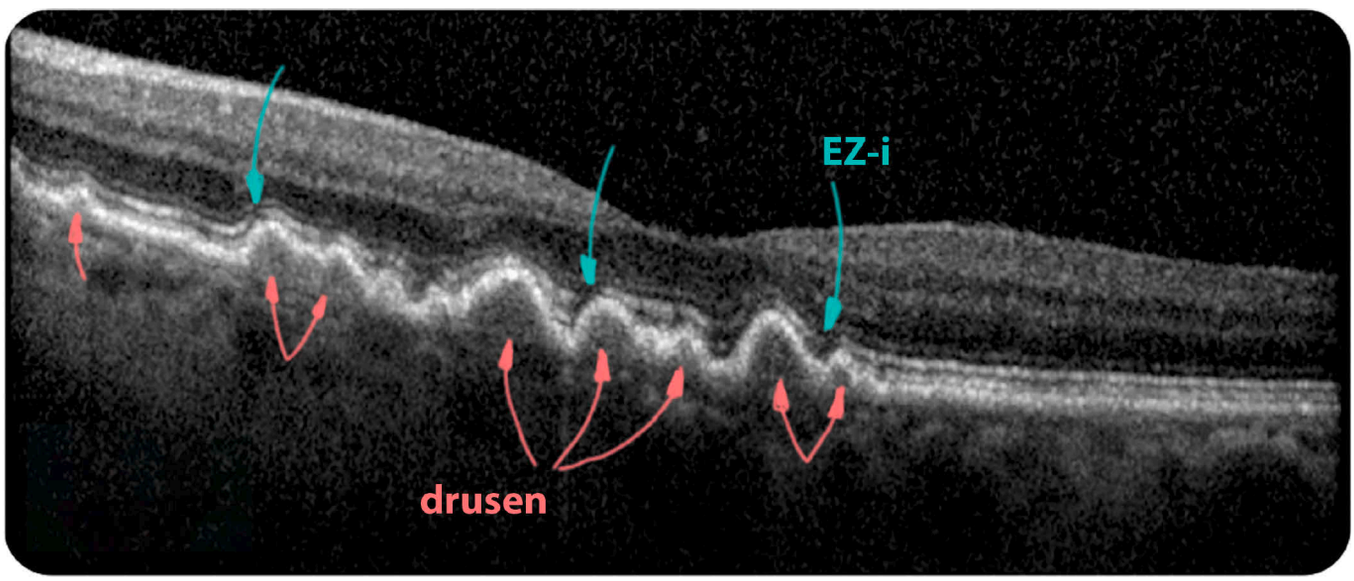
IR Image:
There are multiple large drusen at the fovea.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 28



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple, confluent
Subretinal	PR	EZ fragmented

Interpretation

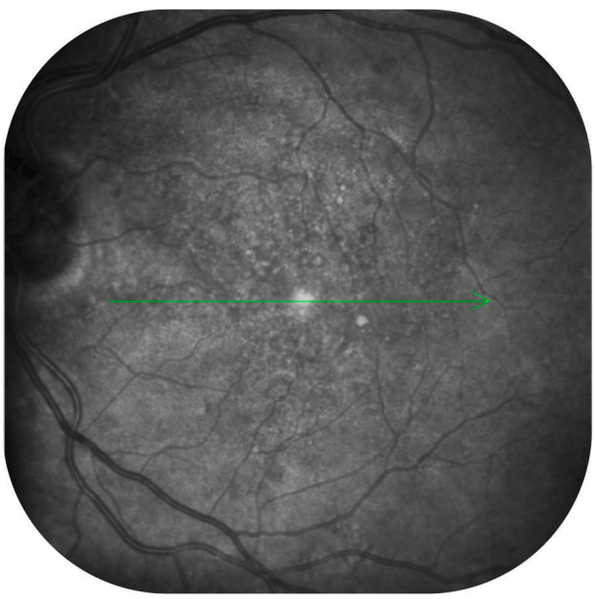
This patient has multiple confluent drusen which interrupt the EZ at multiple points. These findings are consistent with **intermediate AMD** and leave this patient with an inferior visual prognosis.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PR**: Photoreceptor – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption

Case 29

Case 29

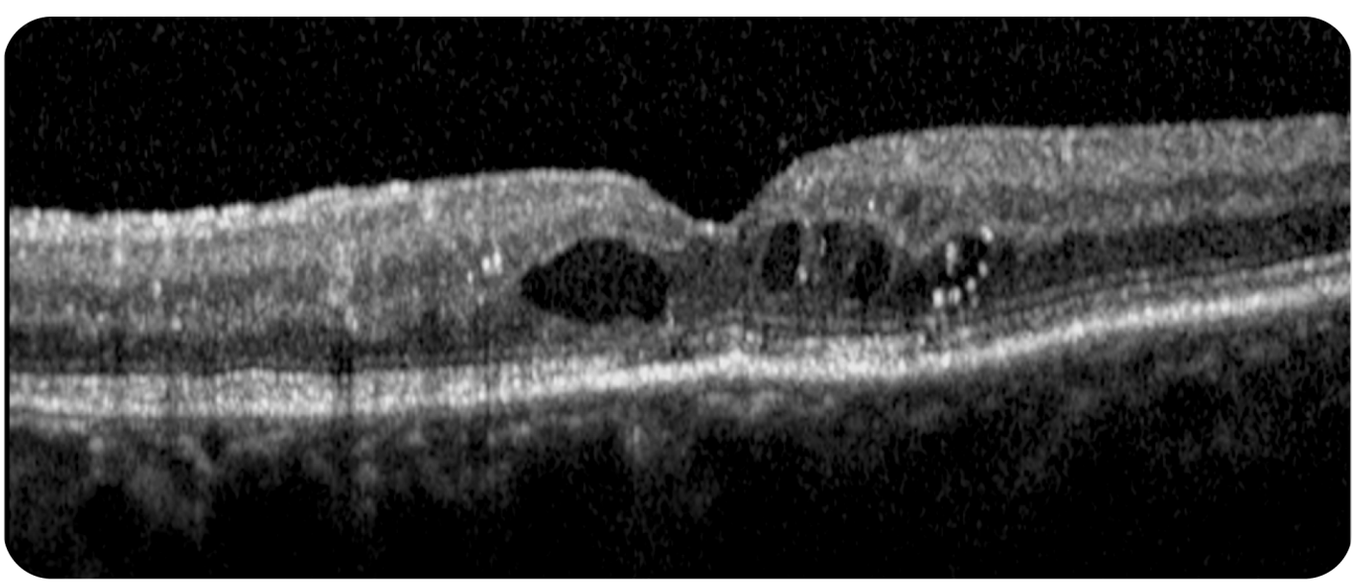
Age 79



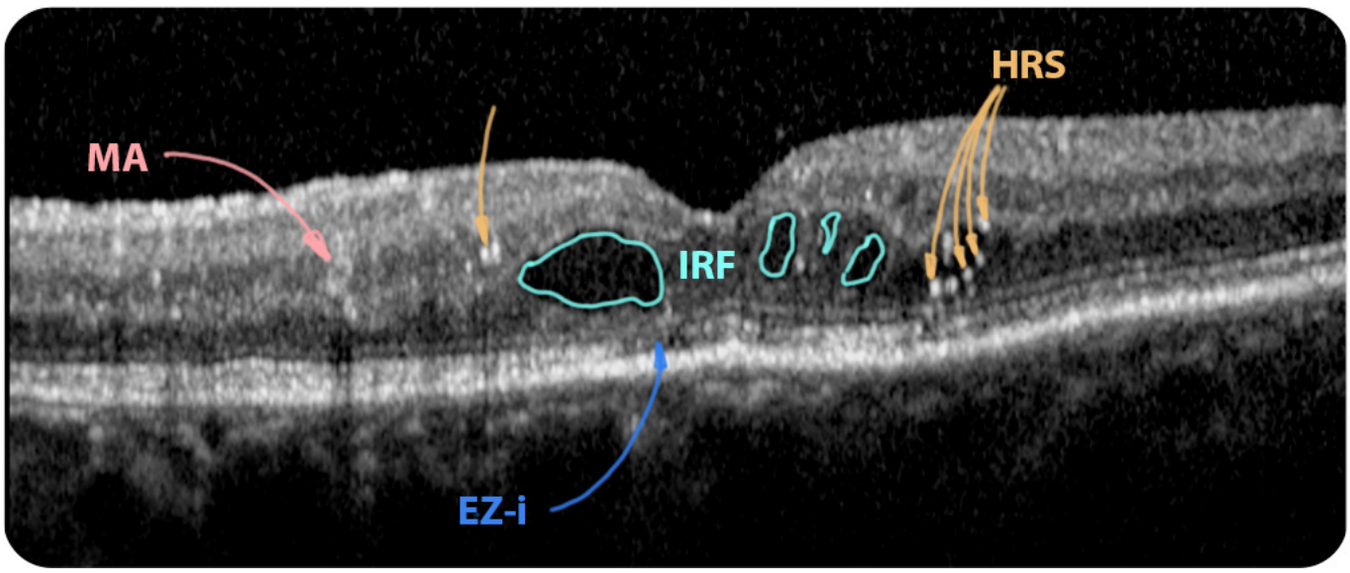
IR Image:
Irregular appearance of entire macula with multiple hyperreflective spots. Central light artifact.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 29



Findings

Area	Alteration	Description
Sub-retinal	PR	EZ is interrupted
Intraretinal	IRF	No thickening
	HRS	Inner and outer retina
	IHRM	Round microaneurysm

Interpretation

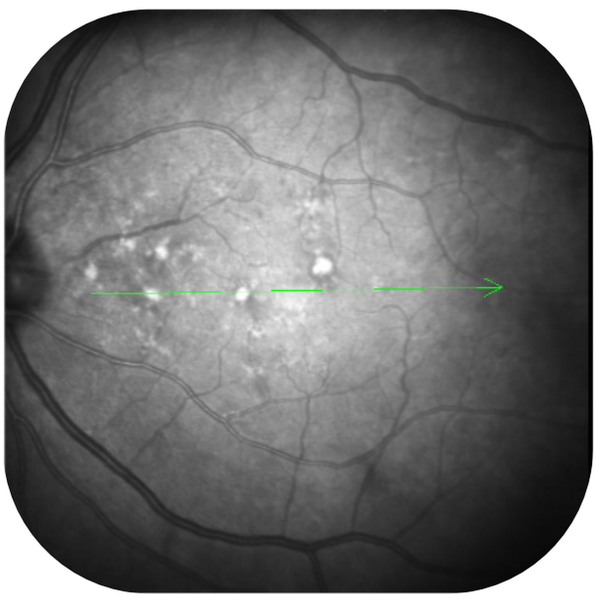
There are multiple relatively large fluid-filled spaces around the fovea, causing only minimal to no retinal thickening. The HRS likely represent exudate or lipid-laden macrophages – a sign of blood-retinal barrier breakdown, which in conjunction with the microaneurysm, are classic signs of **diabetic retinopathy**. There is an interruption of the EZ at the fovea, leaving this patient with a comparatively worse visual prognosis.

PR: Photoreceptors – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **IHRM**: Intraretinal Hyperreflective Material – **MA:** Microaneurysm – **EZ-i:** Ellipsoid Zone Interruption

Case 30

Case 30

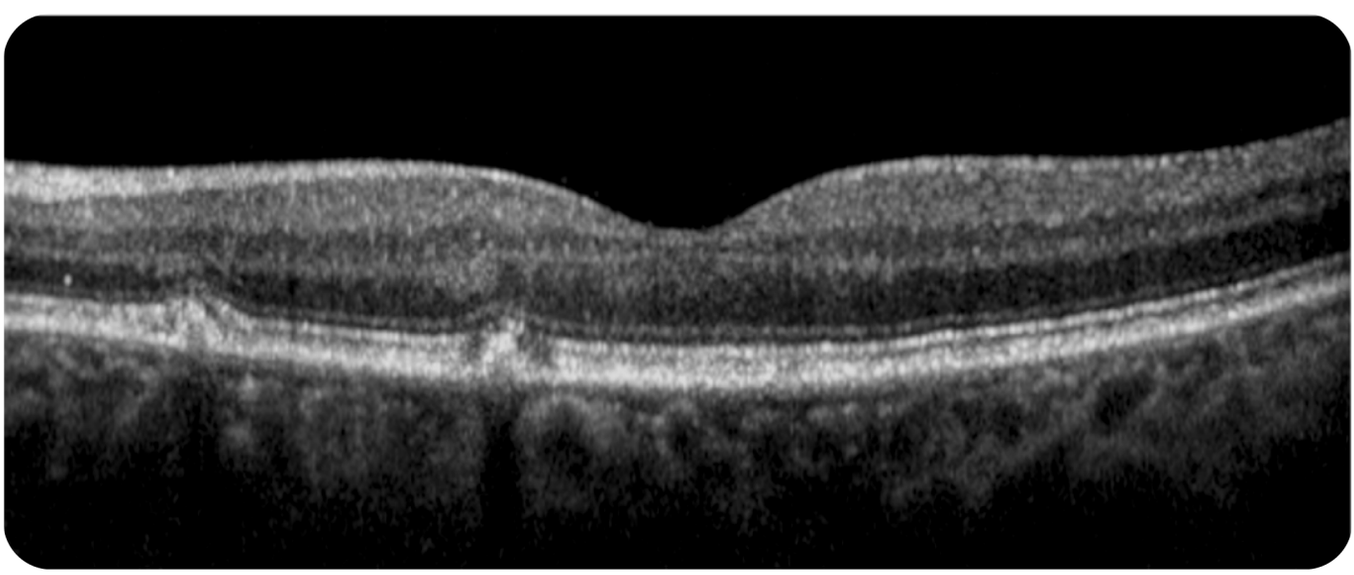
Age 75



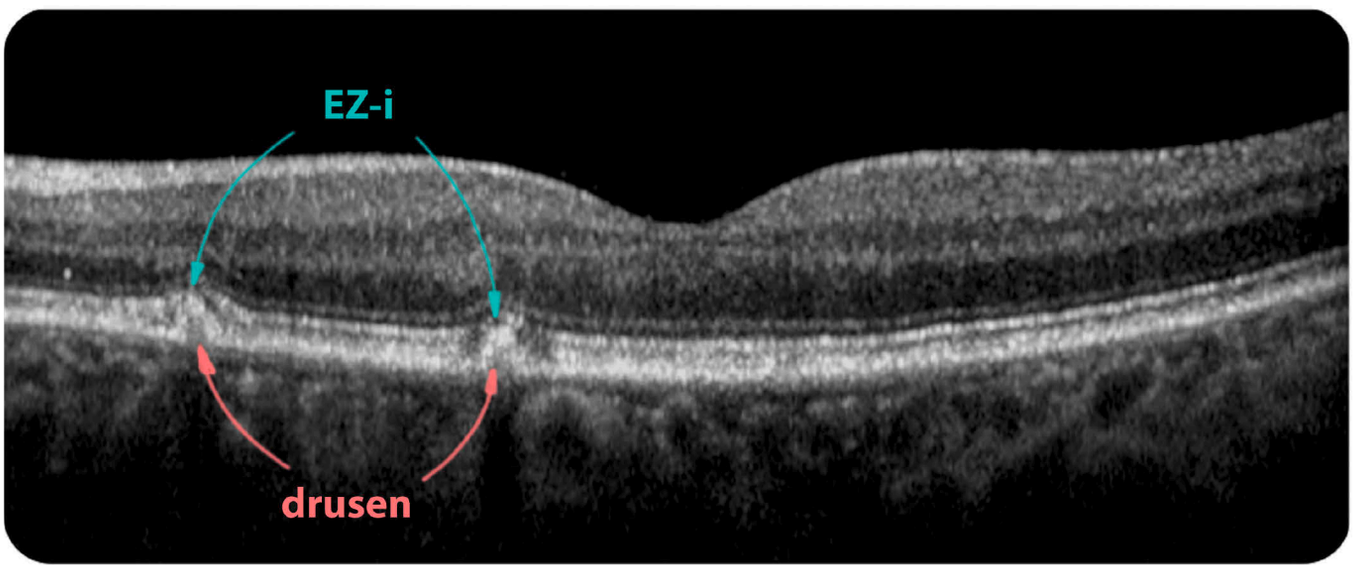
IR Image:
Multiple hyperreflective spots scattered throughout the macula, with a larger concentration temporal to the disc.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 30



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	Drusen	Multiple, hyperreflective
Subretinal	PR	Interrupted EZ

Interpretation

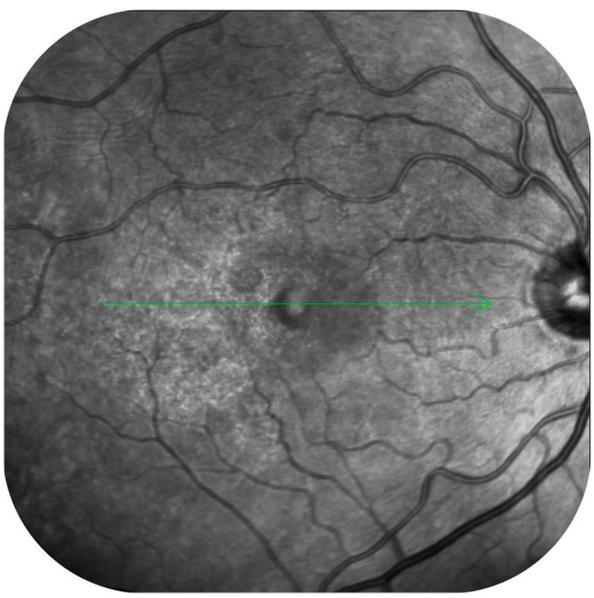
There are two hyperreflective drusen whose appearance is consistent with colloid drusen. The EZ, although noticeably altered, is not clearly interrupted. This patient is likely suffering from **AMD**.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PR**: Photoreceptors – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption

Case 31

Case 31

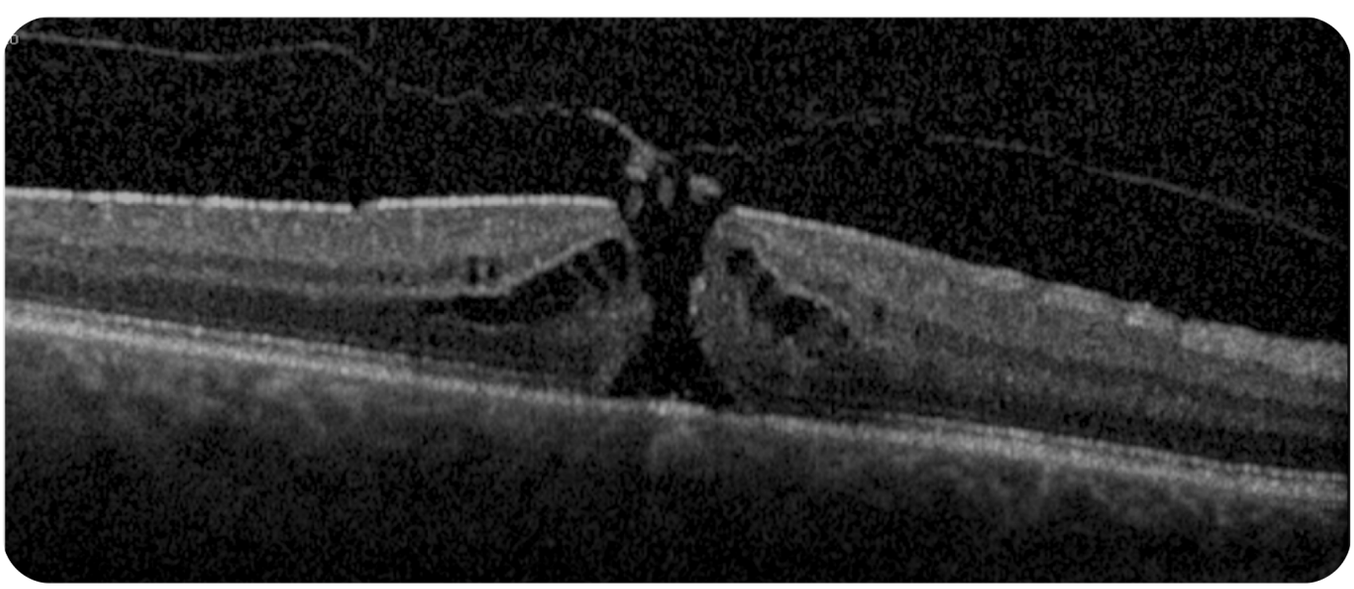
Age 60



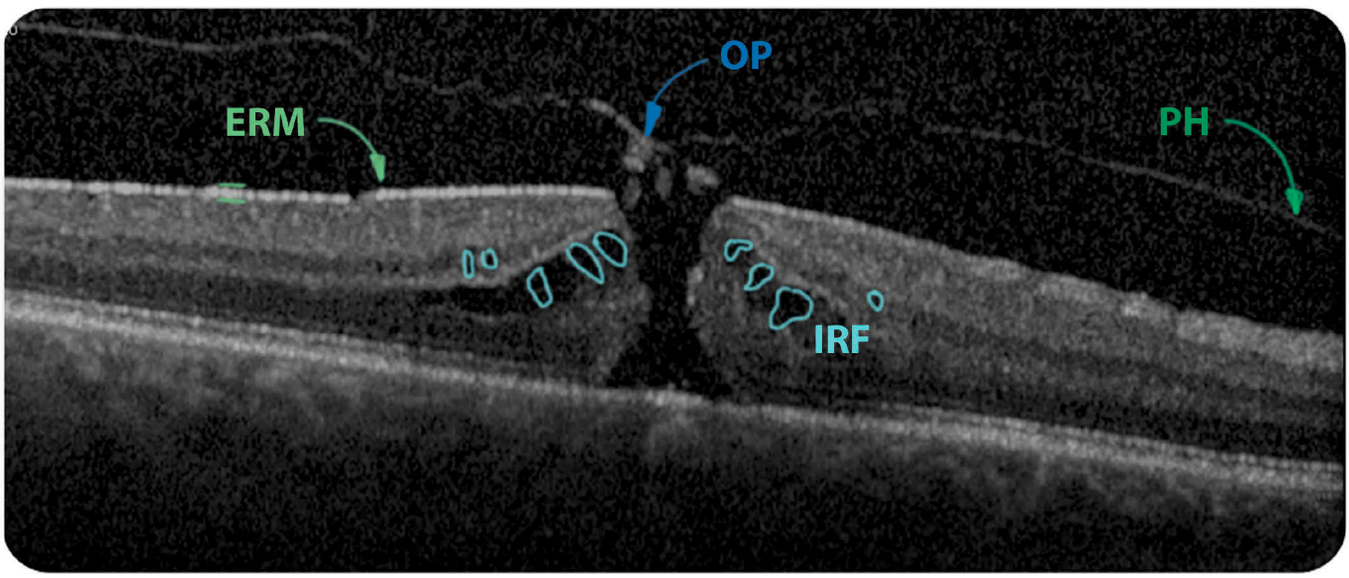
IR Image:
A dark, sickle-shaped alteration is centered at the fovea, and surrounded by hyporeflective alterations.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 31



Findings

Area	Alteration	Description
Subretinal	PR	EZ and PR disrupted
Intraretinal	IRF	Causing retinal thickening
Epiretinal	ERM	Distinct
	MH	Full-thickness macular hole

Interpretation

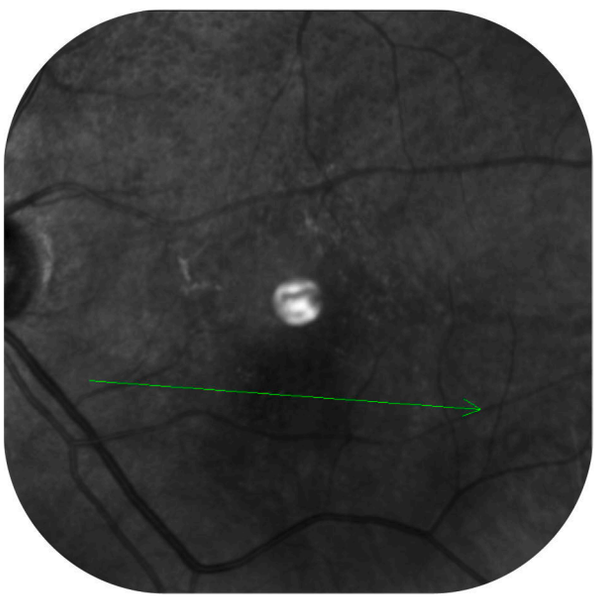
This **full-thickness macular hole** shows complete interruption of all retinal layers down to the RPE. It is accompanied by an accumulation of IRF (slight edema) and an ERM. In addition, the posterior hyaloid with attached retinal tissue (operculum, (OP)) is visible.

PR Photoreceptor – **IRF**: Intraretinal Fluid – **ERM**: Epiretinal Membrane – **MH**: Macular Hole – **OP**: Operculum
PH: Posterior Hyaloid – **RPE:** Retinal Pigment Epithelium

Case 32

Case 32

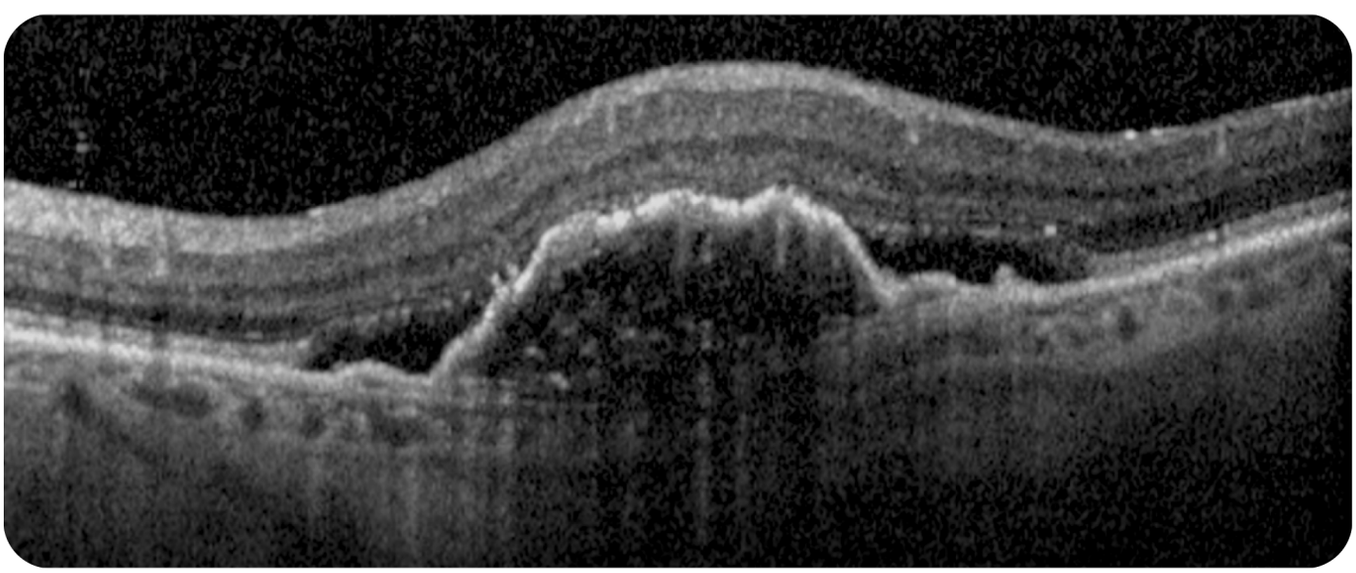
Age 87



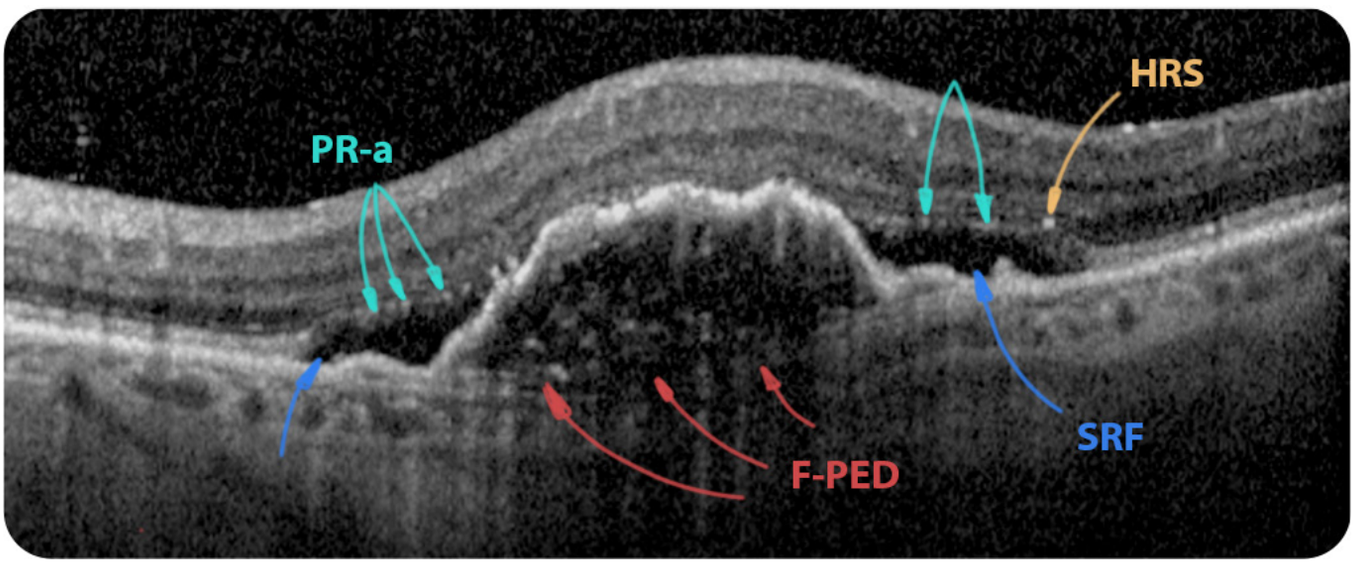
IR Image:
This poorly illuminated IR image with a central light artifact is almost insufficient for assessment. However, a hyporeflective area inferior to the macula can be noted.

Scan Quality:
Good with no artifacts

Location:
Perifovea



Case 32



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	F-PED with associated SRF
Subretinal	SRF	Exudation
	PR	Granulated/atrophic appearance
Intraretinal	HRS	Associated to PR atrophy

Interpretation

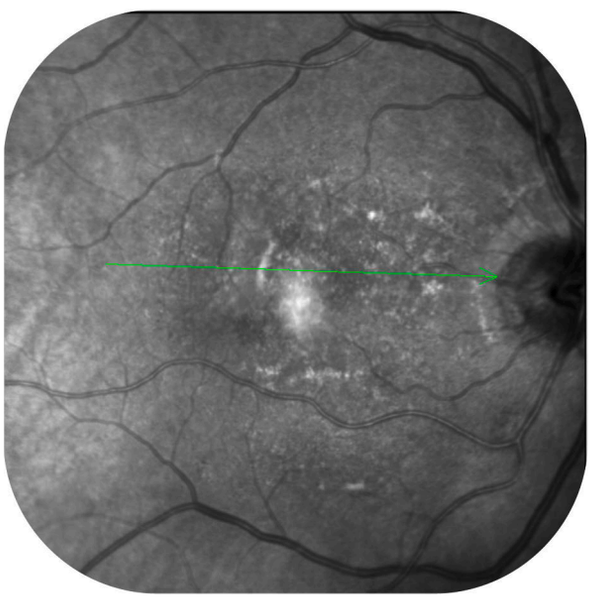
This patient has a large fibrovascular PED with associated SRF, consistent with **an active type 1 MNV**. The PRs, including the ONL look thinned/atrophic, and the HRS in this context likely represent degenerated retinal tissue or macrophages engulfing it.

RPE: Retinal Pigment Epithelial Detachment – **PED**: Pigment Epithelial Detachment – **F-PED:** Fibrovascular PED – **SRF**: Subretinal Fluid – **PR**: Photoreceptor - **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization – **ONL:** Outer Nuclear Layer – **PR-a:** Photoreceptor Atrophy

Case 33

Case 33

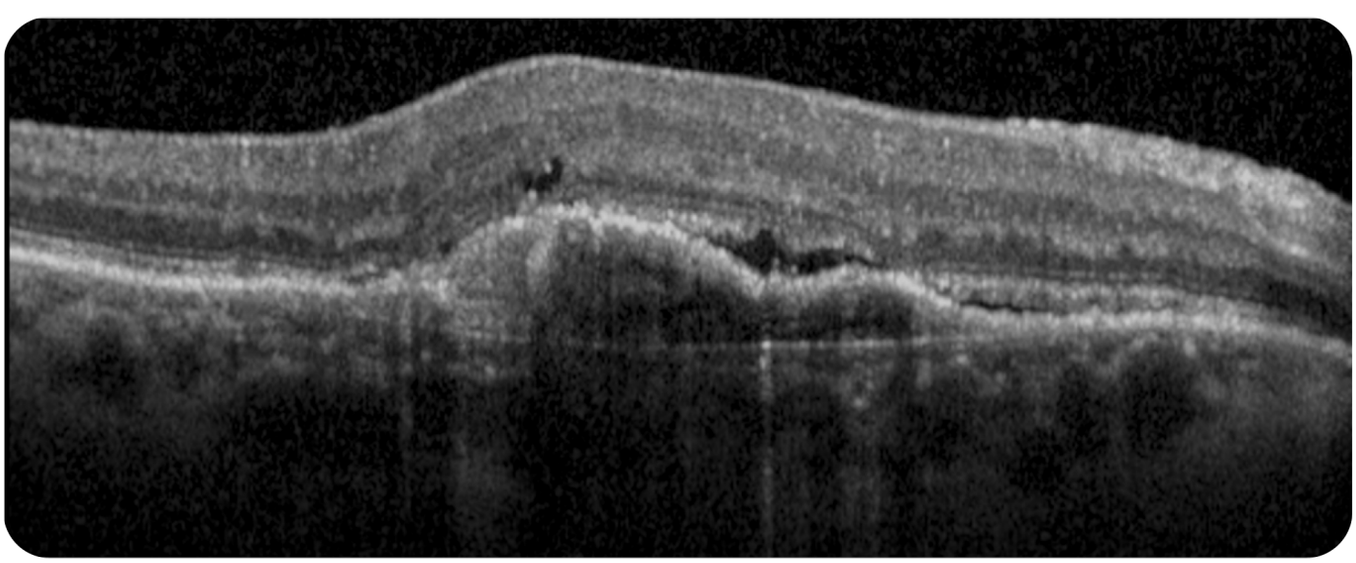
Age 74



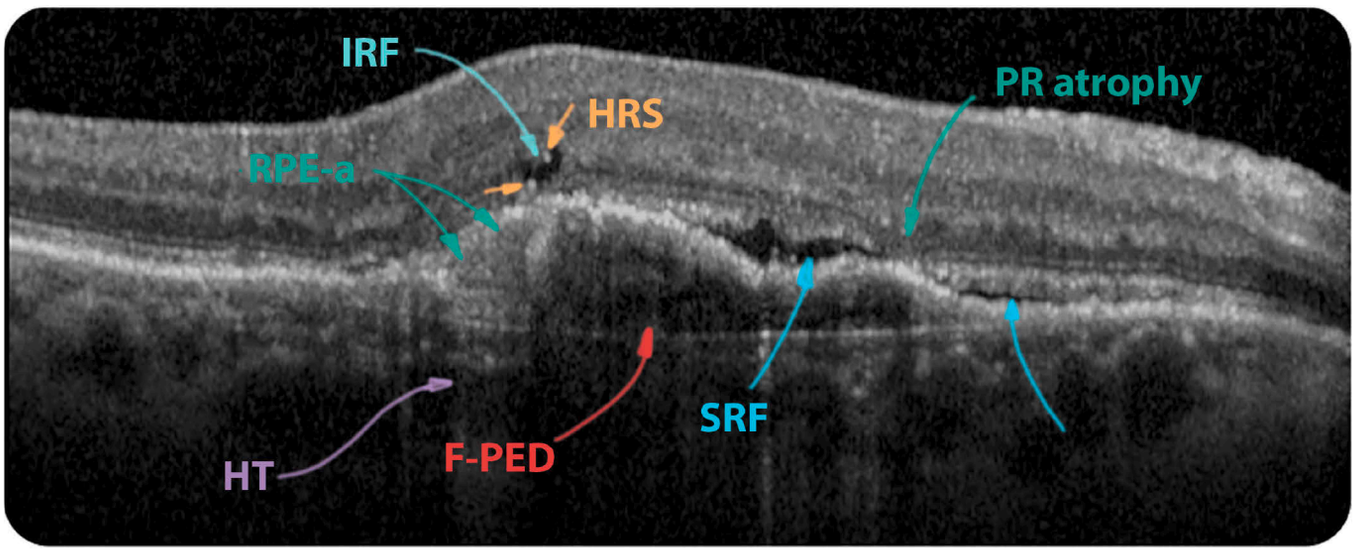
IR Image:
Concentration of hyperreflective tissue central to the macula surrounded by multiple hyperreflective spots, and a hyporeflective parafoveal region.

Scan Quality:
Good with no artifacts

Location:
Parafoveal macula



Case 33



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, interrupted
	PED	F-PED
Subretinal	SRF	Exudation
	PR	PR atrophy
Intraretinal	IRF	Localized
	HRS	Associated to retinal degeneration

Interpretation

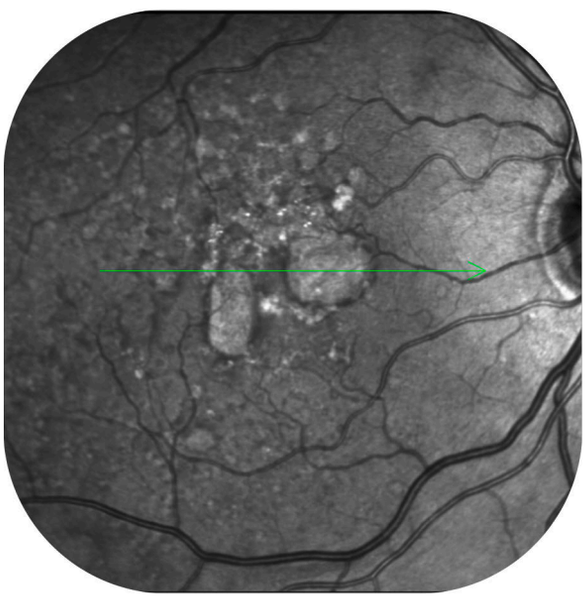
This patient has a fibrovascular PED with associated SRF, consistent with an **active type 1 MNV**. There is an area of RPE atrophy with signal hypertransmission (HT) posterior to it. The EZ is interrupted multiple times, and there is also localized PR atrophy – both indicating chronicity of the disease. The accumulation of IRF is likely due to a local retinal defect, and the adjacent HRS could represent degenerated retinal tissue or macrophages engulfing it.

RPE: Retinal Pigment Epithelium – **RPE-a:** RPE Atrophy – **PED**: Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization – **HT**: Hypertransmission – **EZ:** Ellipsoid Zone

Case 34

Case 34

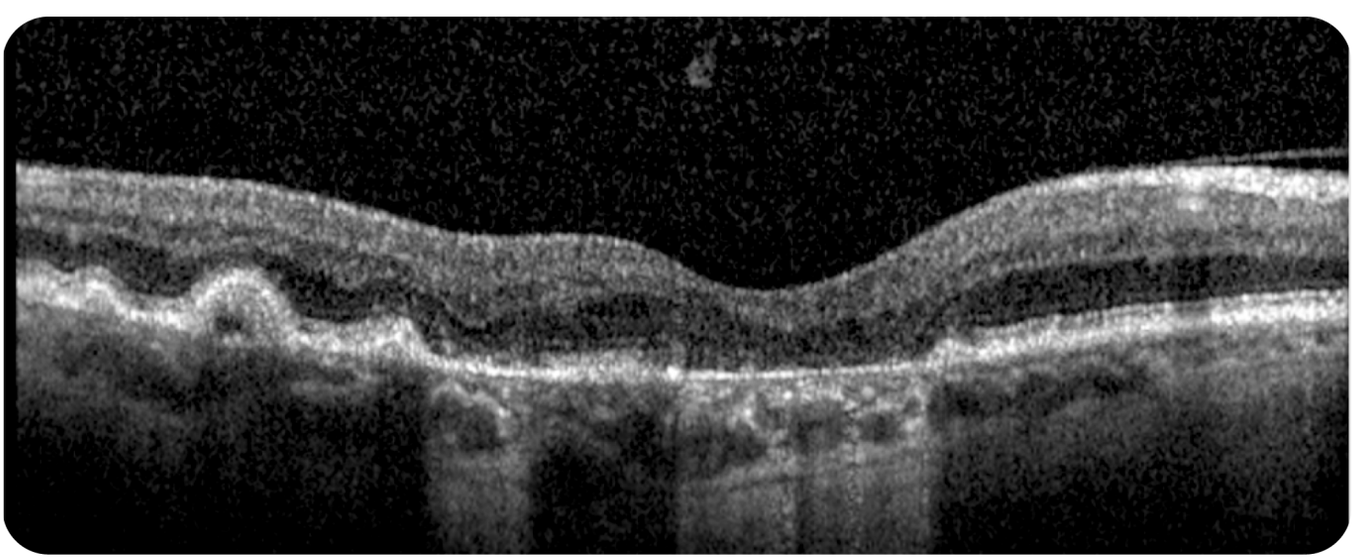
Age 80



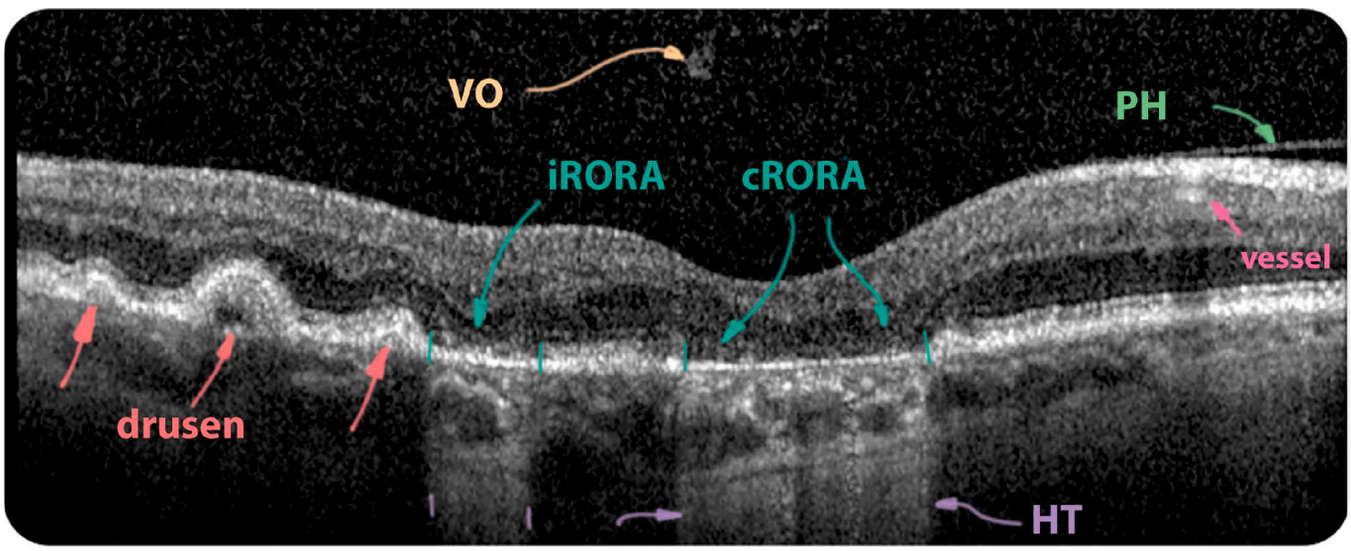
IR Image:
There are multiple hyperreflective areas with visualized choroidal vessels.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 34



Findings

Area	Alteration	Description
Sub-RPE	RPE	Interrupted, elevated
	PED	Drusen
	Atrophy	GA (cRORA and iRORA)
Subretinal	PR	Atrophy
Preretinal	PH	Posterior hyaloid
	VO	Vitreous opacity

Interpretation

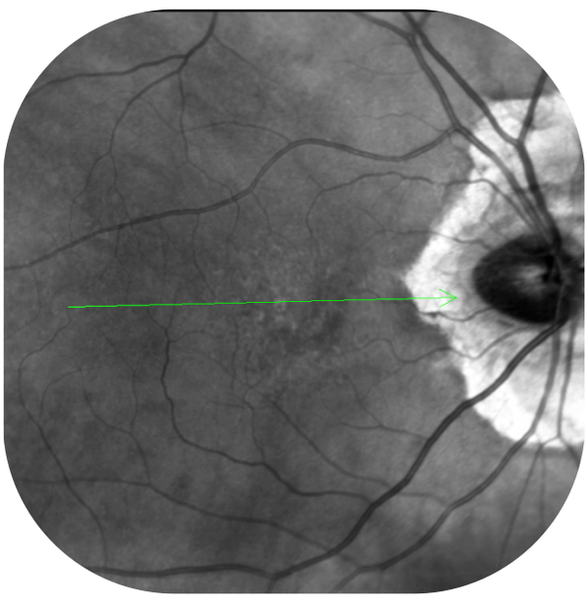
In this scan, we can see two areas of RPE and PR atrophy with adjacent signal hypertransmission, as well as multiple drusen of varying sizes. These findings are very consistent with a **GA secondary to AMD (cRORA)**. In addition, in the preretinal area, one can find a VO and the posterior hyaloid.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **PR**: Photoreceptor – **PH**: Posterior Hyaloid – **VO**: Vitreous Opacity – **HT:** Hypertransmission – **GA**: Geographic Atrophy – **iRORA:** Incomplete RPE and Outer Retinal Atrophy – **cRORA**: Complete RPE and Outer Retinal Atrophy

Case 35

Case 35

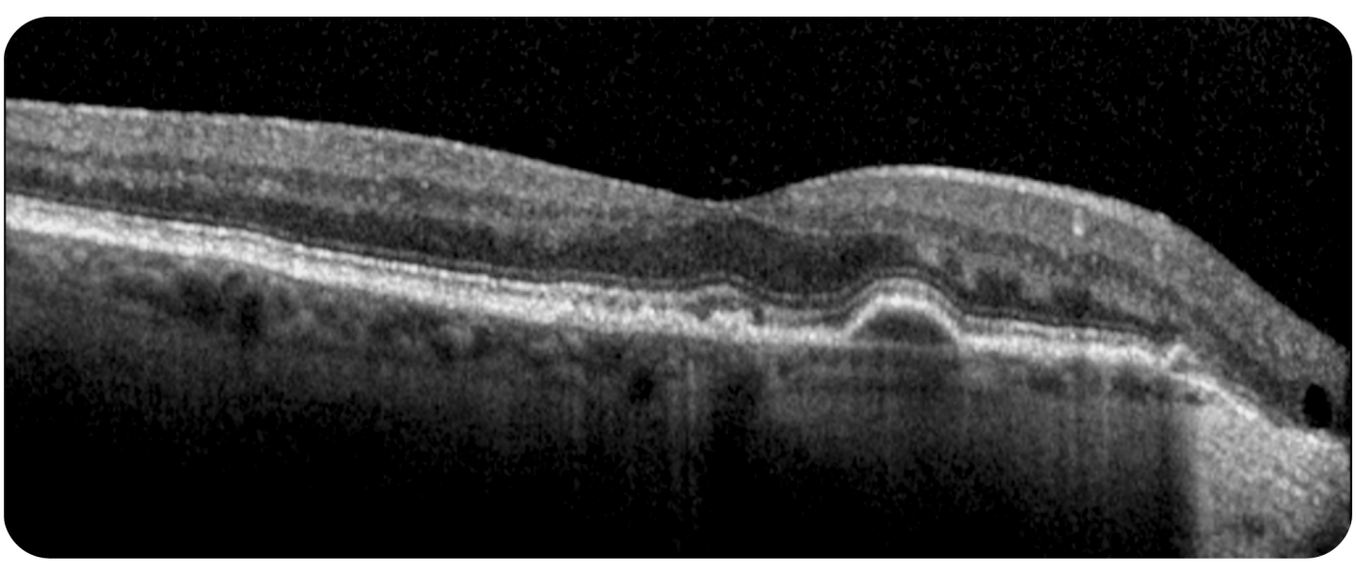
Age 66



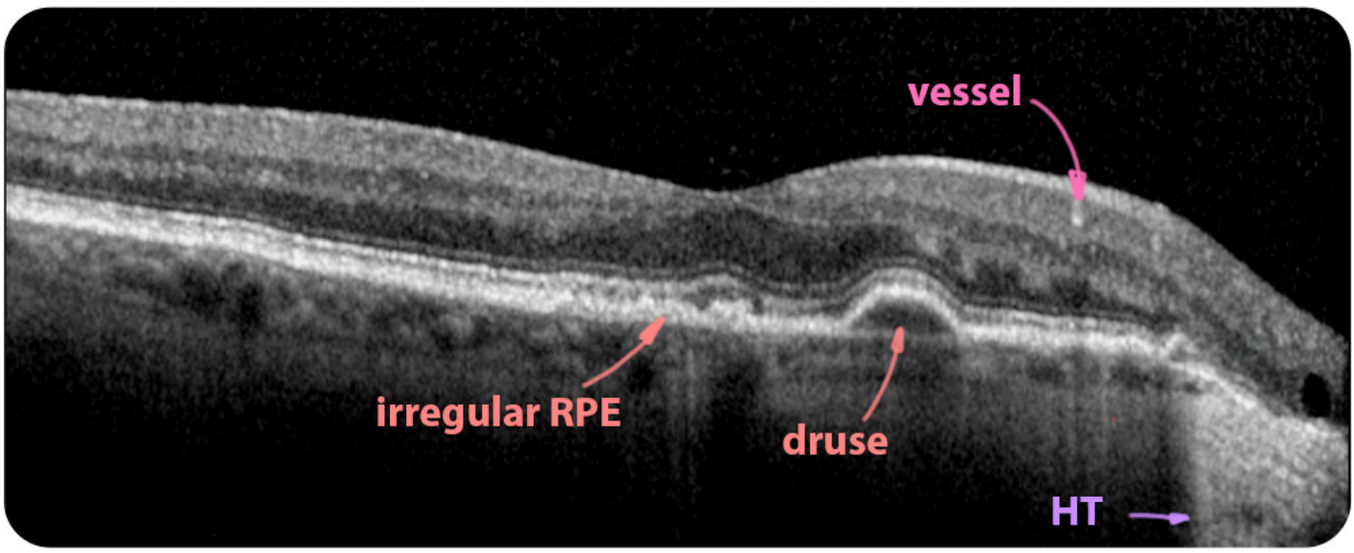
IR Image:
The foveal and parafoveal areas have a slightly irregular appearance. In addition, there is peripapillary chorioretinal atrophy, as well as a tilted disc.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 35



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	PED	Drusen
	Atrophy	Peripapillary atrophy

Interpretation

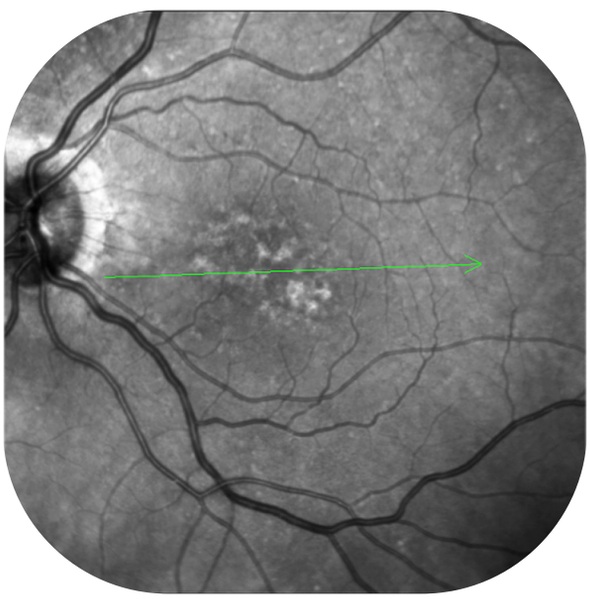
The area of shallow RPE irregularity shows no DLS and no signs of active exudation – most likely representing a drusenoid alteration. The druse has a hyporeflective and homogeneous appearance. The tilted disc and chorioretinal atrophy are common in myopic patients so, we are very likely looking at a **myopic** patient with **early signs of AMD**.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **DLS**: Double-layer Sign – **HT:** Hypertransmission

Case 36

Case 36

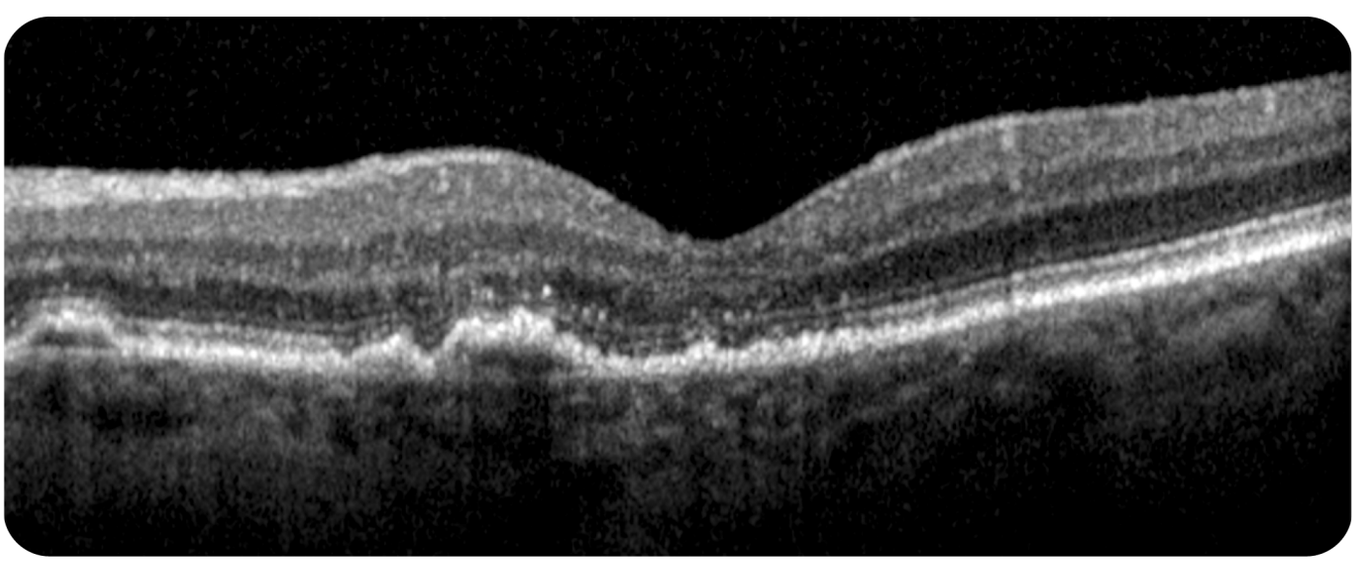
Age 83



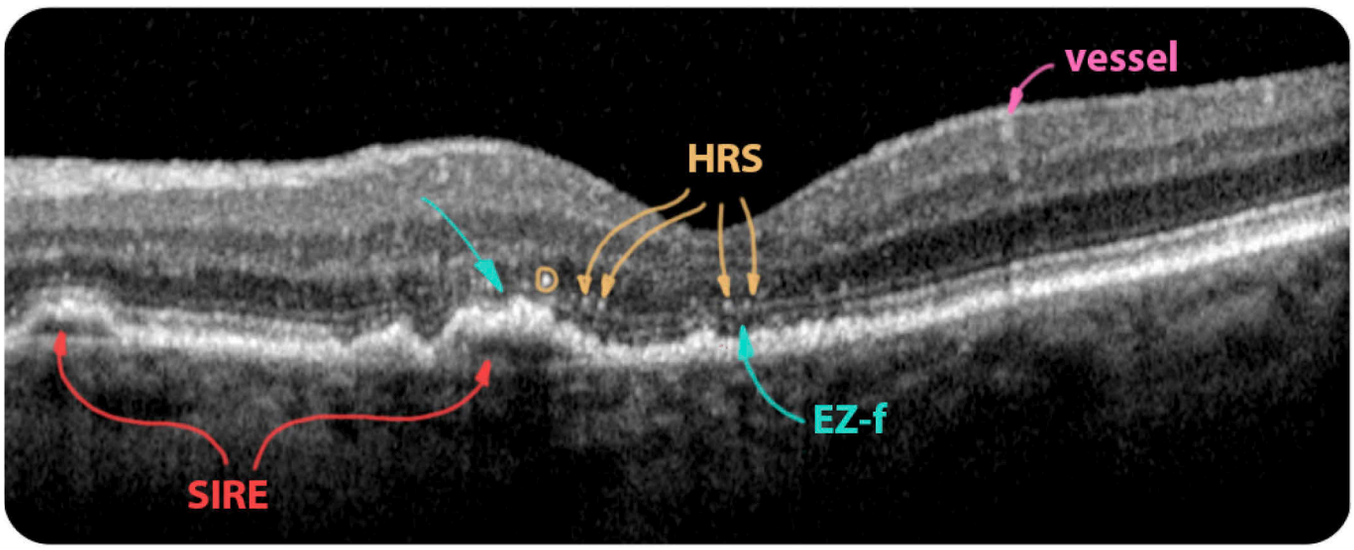
IR Image:
Irregular appearance of the perifoveal area with bright confluent alterations over a darker background.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 36



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	SIRE	Heterogenous irregular PED elevation
Subretinal	PR	EZ fragmentation
Intraretinal	HRS	Associated with RPE alterations and PR-atrophy

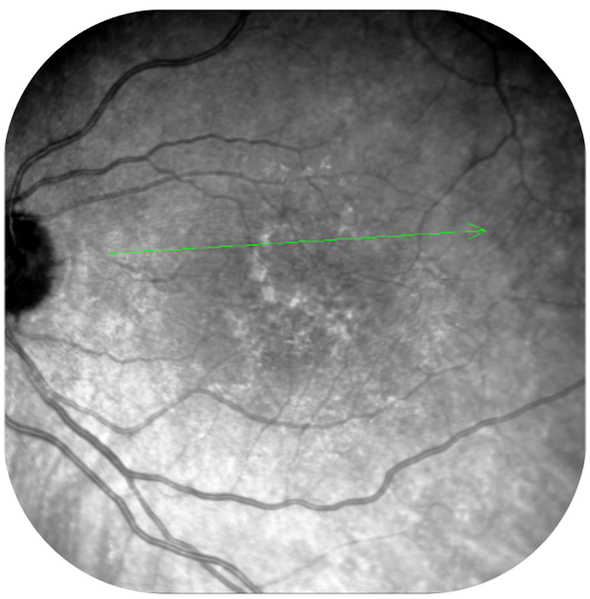
Interpretation

The two shallow irregular RPE elevations (SIRE) with a positive DLS are highly suspicious for **quiescent MNV**. The HRS are mainly located around the ELM and could represent retinal degeneration or be a sign of AMD progression. The EZ is interrupted at the fovea, leaving this patient with an inferior visual prognosis.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **DLS**: Double Layer Sign – **PED:** Pigment Epithelial Detachment – **MNV**: Macular Neovascularization – **ELM**: External Limiting Membrane – **EZ:** Ellipsoid Zone – **EZ-f**: Ellipsoid Zone Fragmentation

Case 37

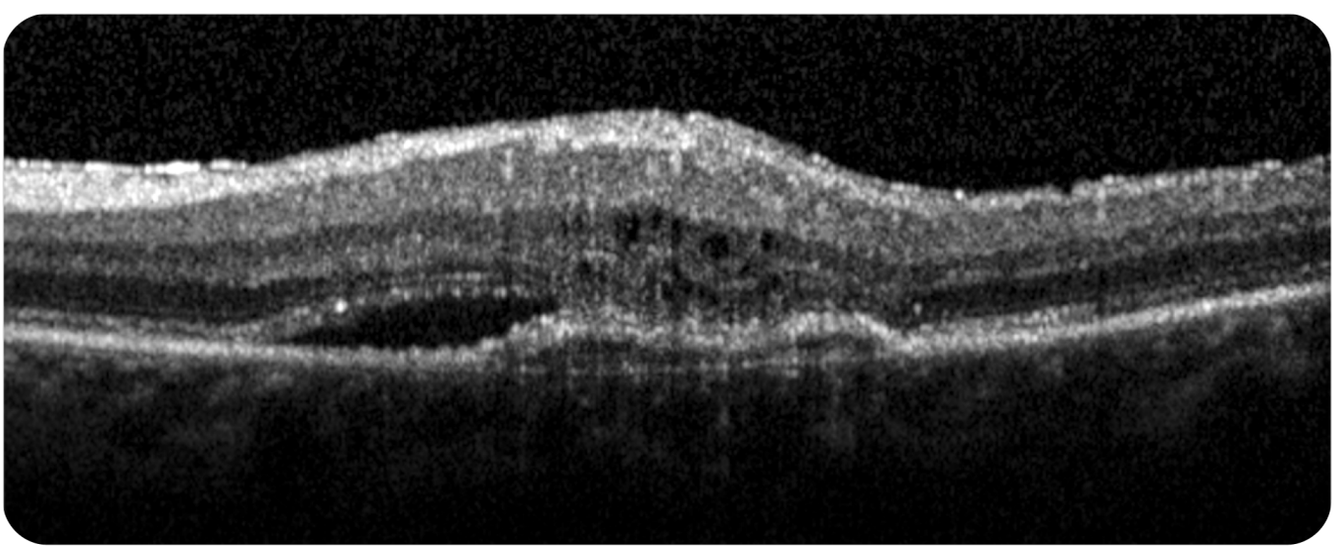
Age 74



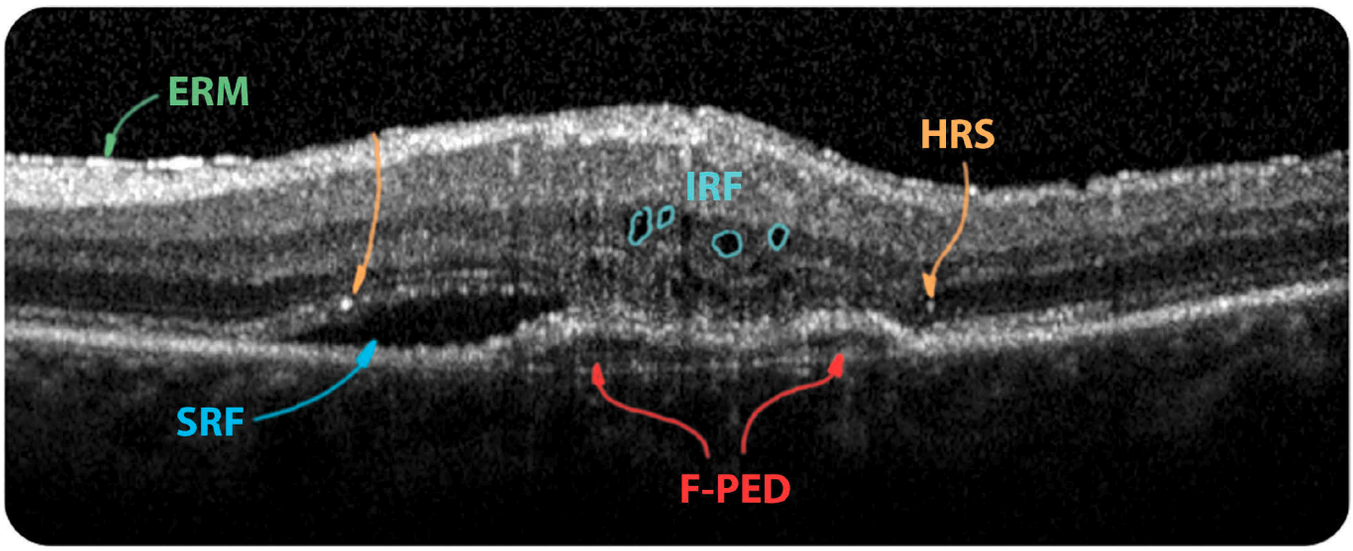
IR Image:
There is an irregular appearance of the macula with bright confluent areas over a darker background.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 37



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	PED	Fibrovascular PED with associated SRF
Subretinal	PR	EZ ill defined, thinning of the PR layer
Intraretinal	IRF	Causing retinal thickening
	HRS	Associated with degeneration
Epiretinal	ERM	Present

Interpretation

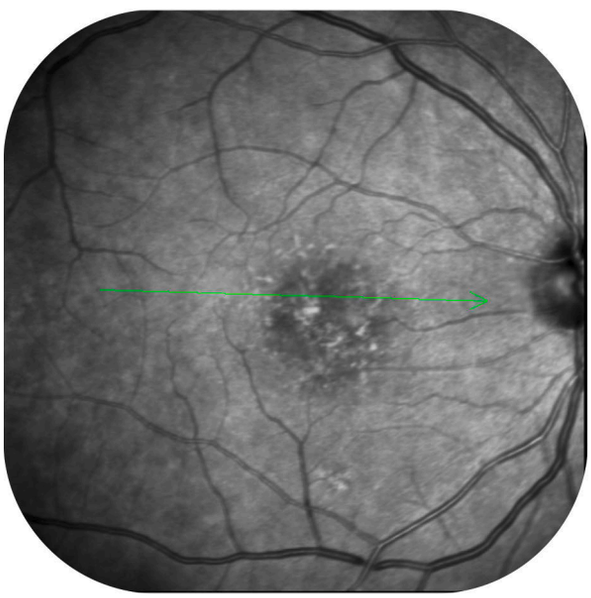
There is a shallow fibrovascular PED with associated SRF and IRF – these findings are highly suspicious for a **type 1 MNV**. In addition, the PRs above the PED are ill-defined, and the ones above the SRF show signs of degeneration. The HRS could represent cellular debris or engulfing macrophages. Finally, there is also a thin ERM.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **IRF**: Intraretinal Fluid – **SRF:** Subretinal Fluid – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization

Case 38

Case 38

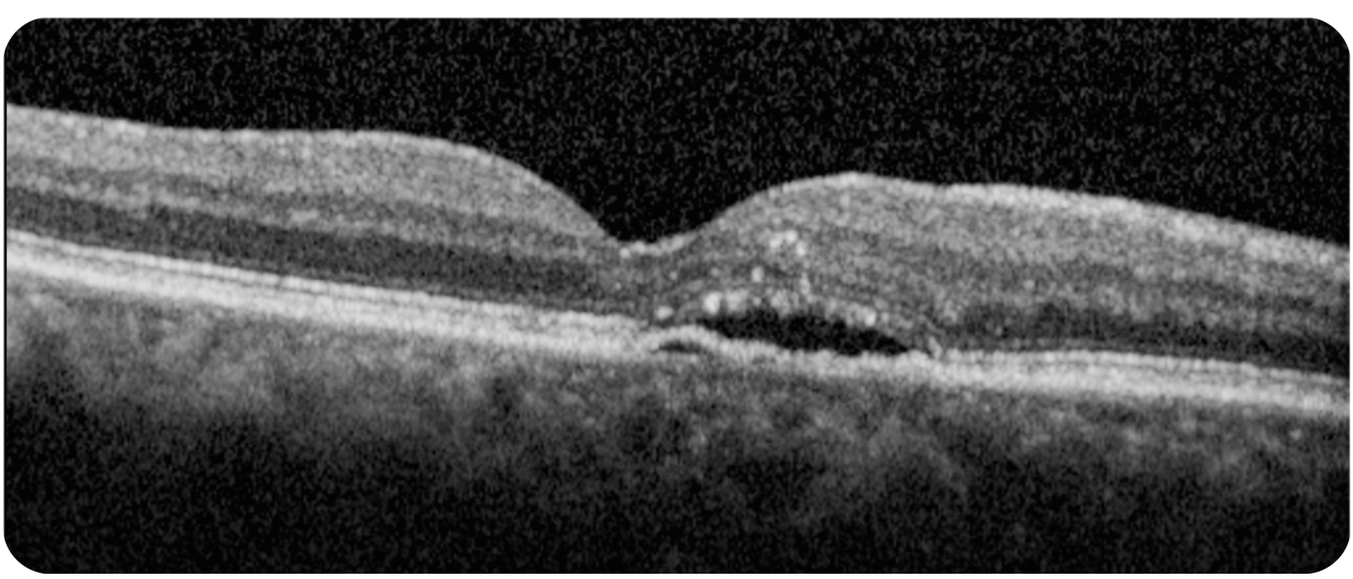
Age 62



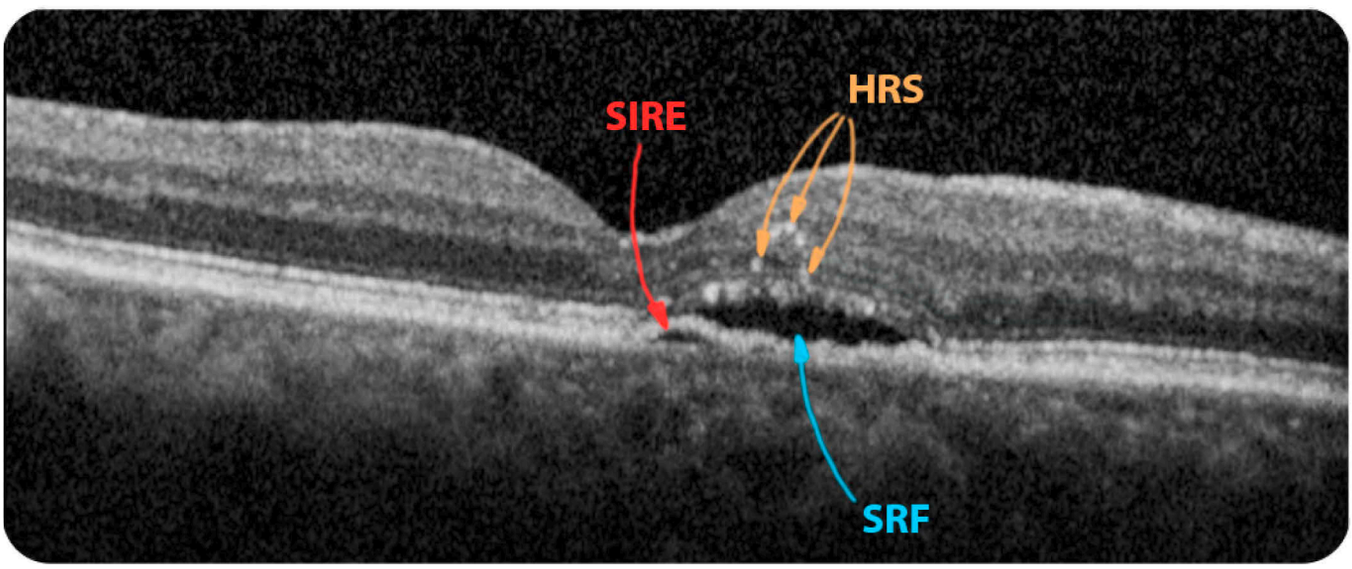
IR Image:
Irregular, darkened appearance of the parafoveal area with a concentration of hyperreflective spots in the fovea.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 38



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	SIRE	With DLS and SRF
Subretinal	SRF	Associated with RPE alteration
	PR	PRs with granulated appearance
Intraretinal	HRS	Associated with degeneration

Interpretation

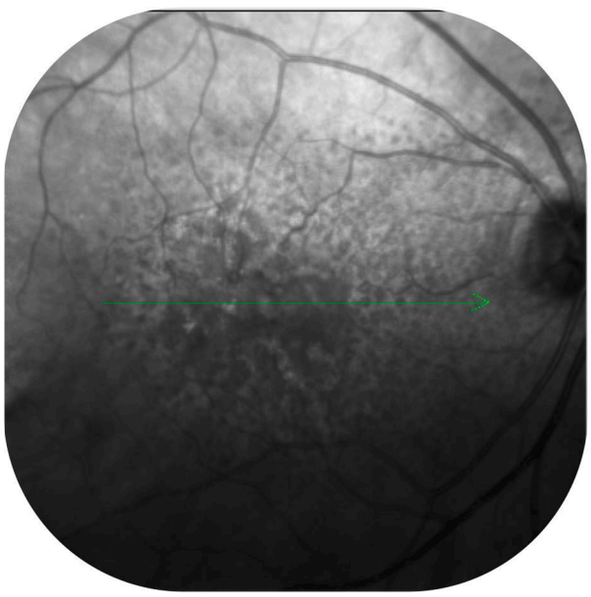
The SIRE with a DLS and adjacent SRF is highly suspicious for an **active type 1 MNV**. In addition, the EZ is ill-defined, and the PRs have a granulated appearance, suggesting a prolonged course of the disease, resulting in a comparatively worse visual prognosis. As there are no signs of drusen and the choroid is not fully visible, CSC is a possible differential diagnosis in this case.

RPE: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **DLS**: Double-layer Sign – **MNV**: Macular Neovascularization – **EZ**: Ellipsoid Zone

Case 39

Case 39

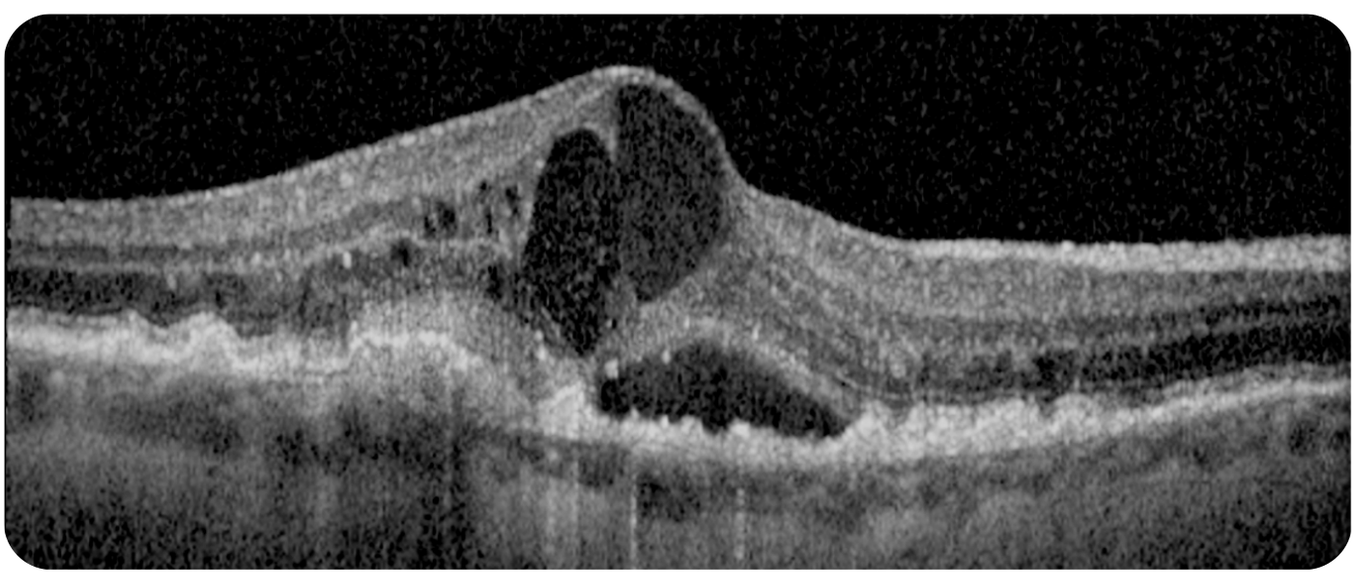
Agee 77



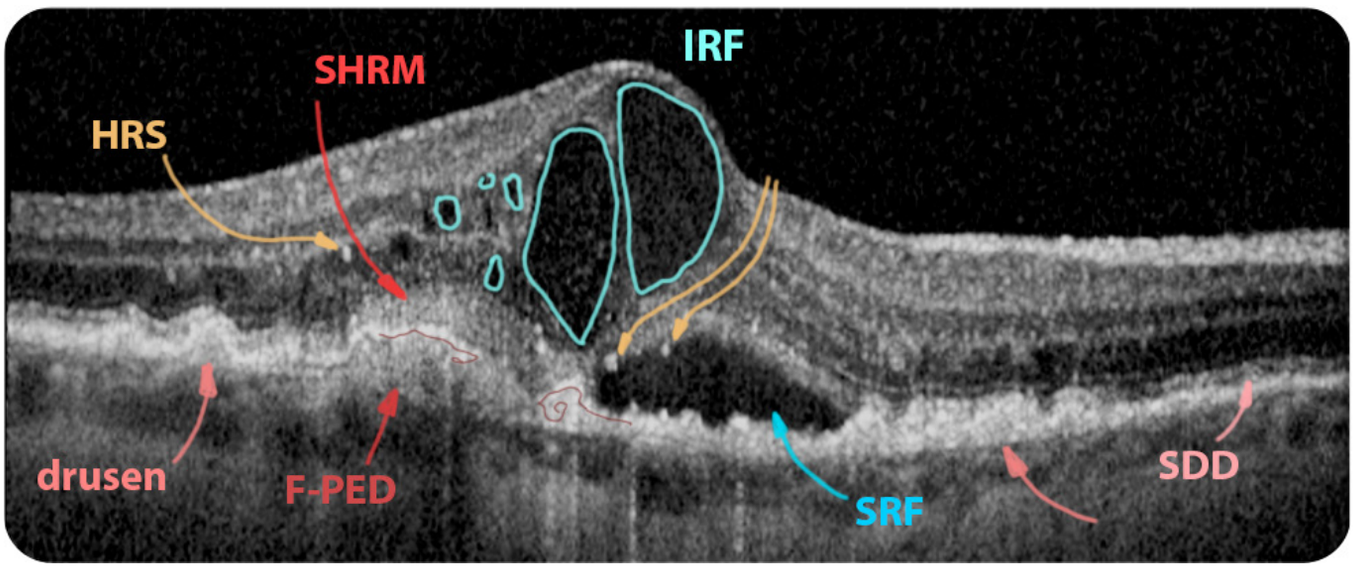
IR Image:
The IR image is misaligned, poorly illuminating the macula inferiorly. There is a widespread scattering of reticular pseudodrusen and drusen surrounding a hyporeflective area at the fovea.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 39



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular, interrupted
	PED	Fibrovascular PED, multiple drusen
Subretinal	SDD	Reticular pseudodrusen
	SHRM	Fuzzy appearance with associated SRF and IRF
	SRF	Due to exudation
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudates, pigment migration

Interpretation

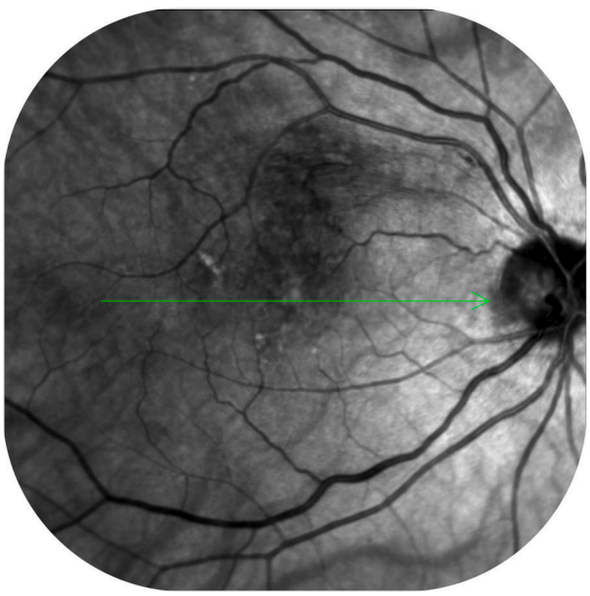
This scan shows a fibrovascular PED with associated SHRM and adjacent accumulation of SRF and IRF. In addition, there are multiple confluent drusen as well as a subretinal drusenoid deposit. Thus, this patient is very likely suffering from an **active mixed Type 1 and 2 MNV secondary to AMD.**

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **SDD**: Subretinal Drusenoid Deposits – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization – **AMD:** Age-related Macular Degeneration

Case 40

Case 40

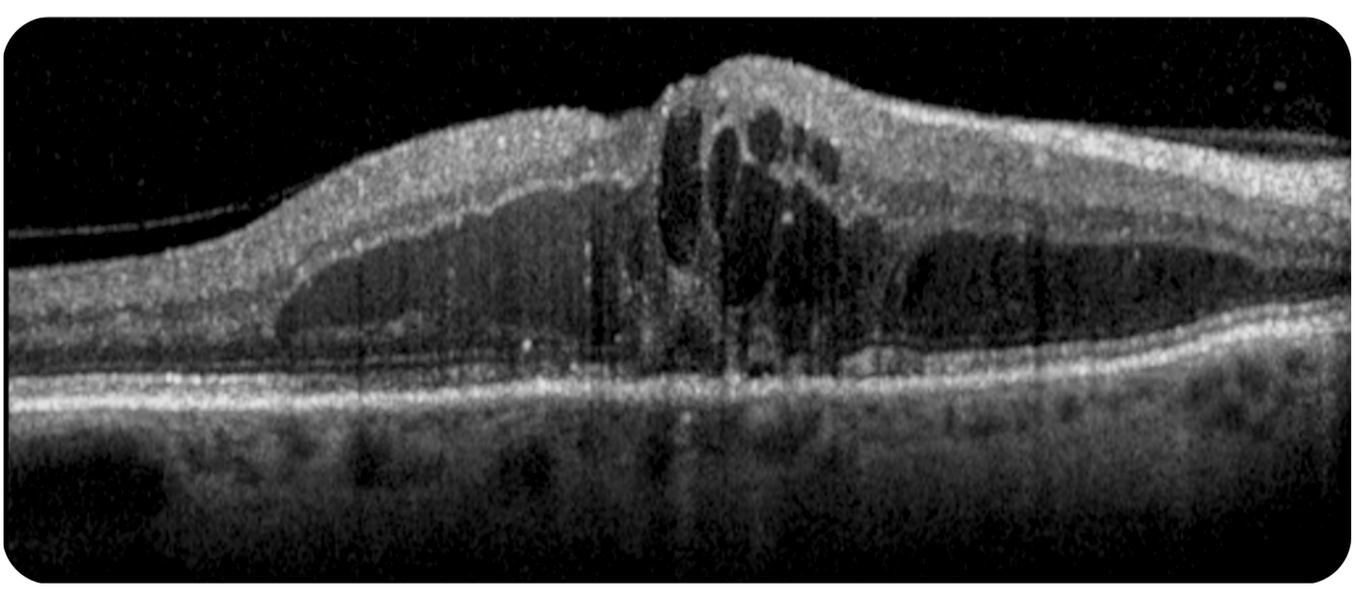
Age 67



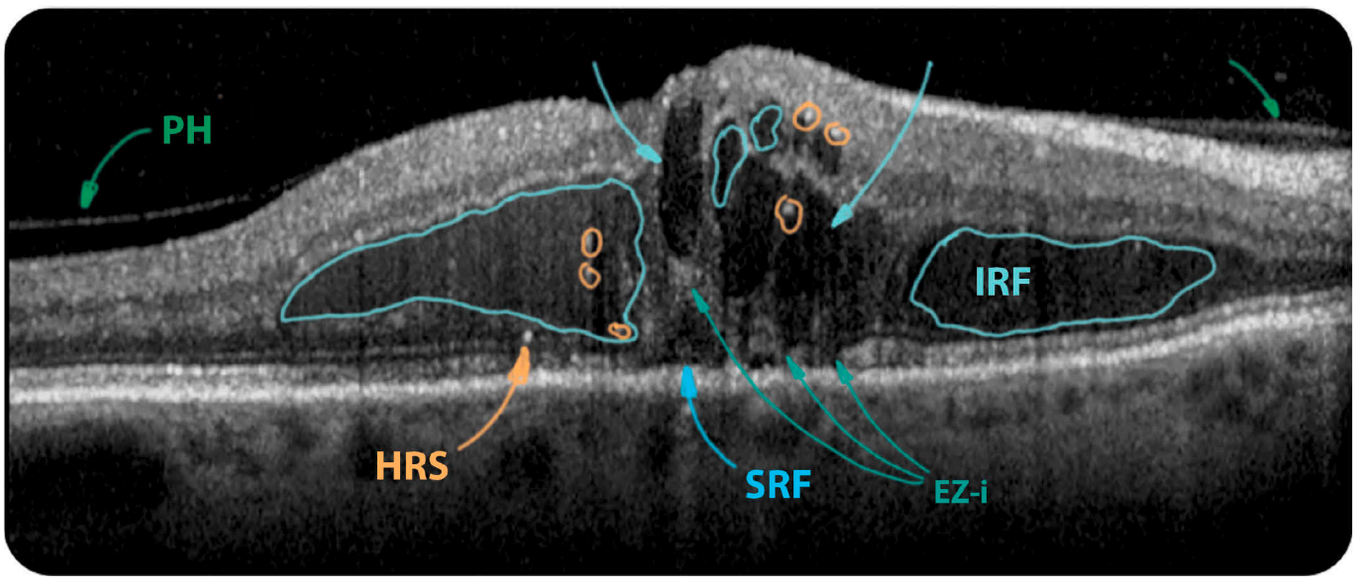
IR Image:
Extended hyporeflective area reaching from the superior vascular arcade down to the fovea. In addition, two hyperreflective spots and a streaky hemorrhage are present.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 40



Findings

Area	Alteration	Description
Subretinal	SRF	Associated with CME
	PR	EZ irregularity
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudate
Preretinal	PH	Posterior hyaloid

Interpretation

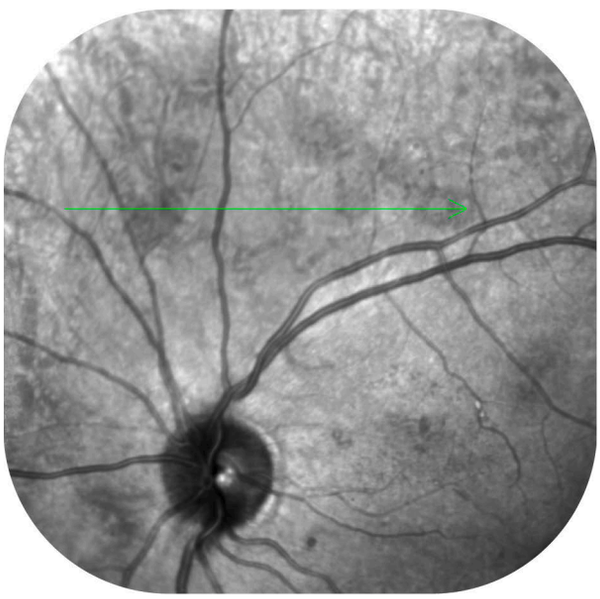
This patient has a pronounced CME with SRF accumulation. The HRS likely represent exudates or lipid-laden macrophages – indicating a retinal vascular disease. In conjunction with the IR image, the findings are consistent with a **CME secondary to a BRVO.** The EZ has an irregular appearance that, however, could be due to shadowing artifacts.

SRF: Subretinal Fluid – **PR**: Photoreceptor – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **PH**: Posterior Hyaloid – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **CME**: Cystoid Macular Edema – **BRVO**: Branch Retinal Vein Occlusion

Case 41

Case 41

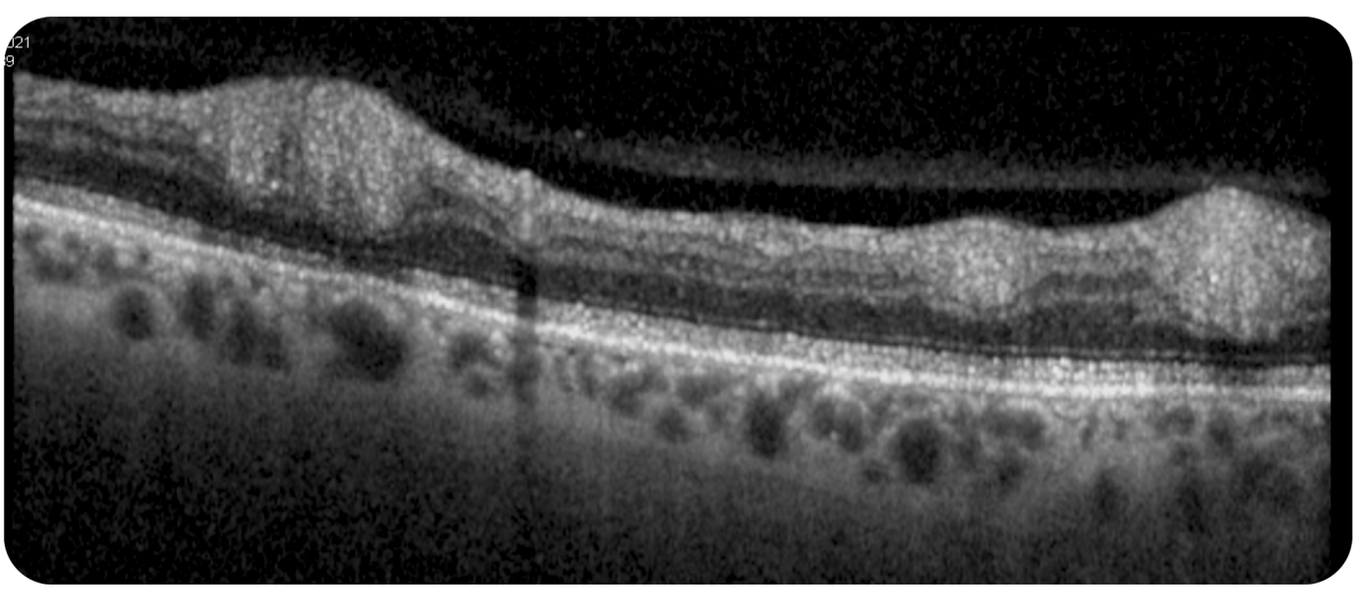
Age 68



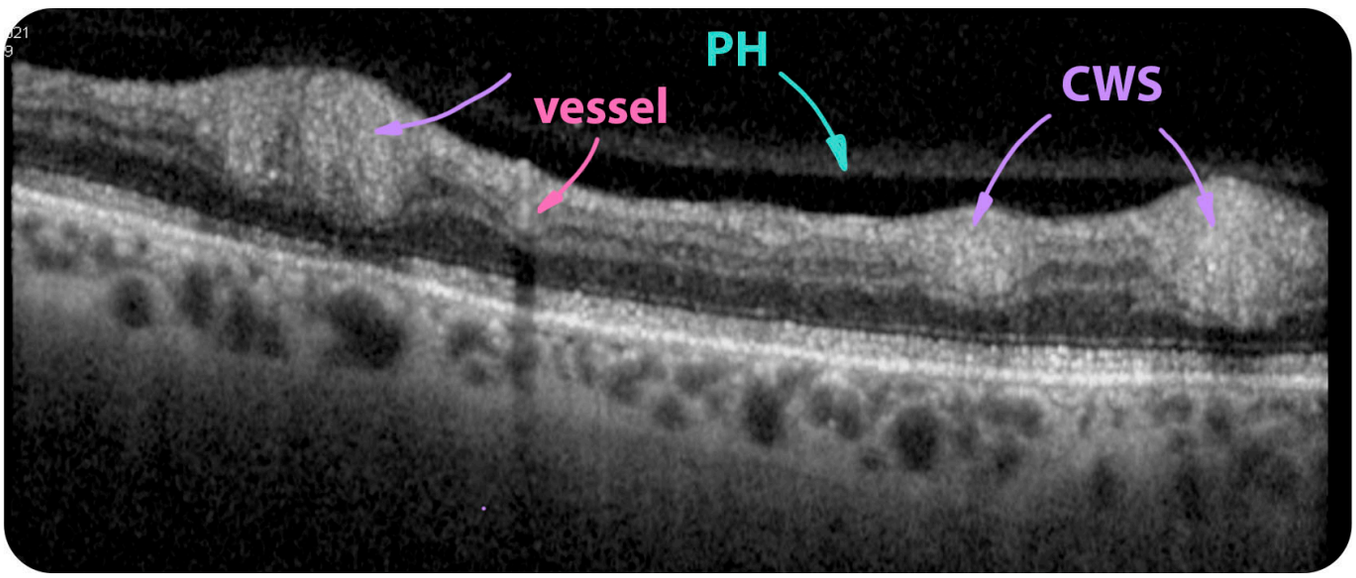
IR Image:
A picture of the superior mid-peripheral retina. There are multiple slightly hyporeflective areas. In the inferior part of the image, there are multiple MAs and two HRS.

Scan Quality:
Good with no artifacts

Location:
Periphery



Case 41



Findings

Area	Alteration	Description
Subretinal	RPE	Irregular, elevated
Intraretinal	IHRM	CWS
Preretinal	PH	Posterior hyaloid

Interpretation

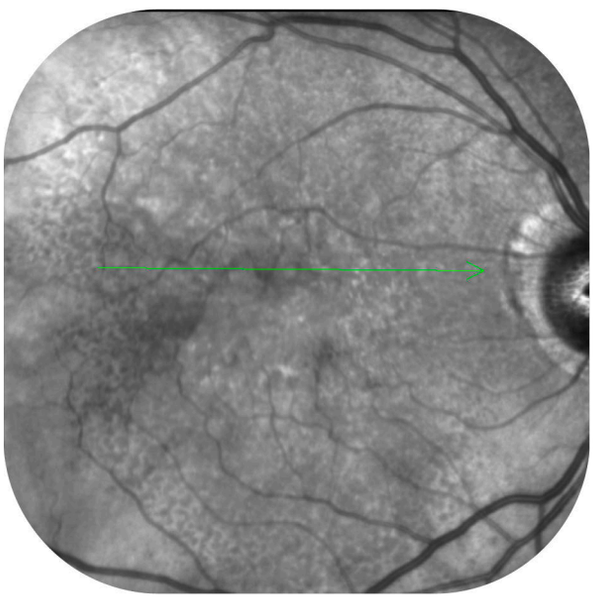
The scan reveals areas of thickened RNFL with minimal adjacent signal blockage, consistent with cotton wool spots (CWS). In conjunction with the IR image (microaneurysms), we are probably looking at a patient with **diabetic retinopathy**.

RPE: Retinal Pigment Epithelium – **IHRM**: Intraretinal Hyperreflective Material – **PH**: Posterior Hyaloid – **CWS**: Cotton Wool Spots – **MA:** Microaneurysm – **HRS:** Hyperreflective Spots – **RNFL:** Retinal Nerve Fiber Layer

Case 42

Case 42

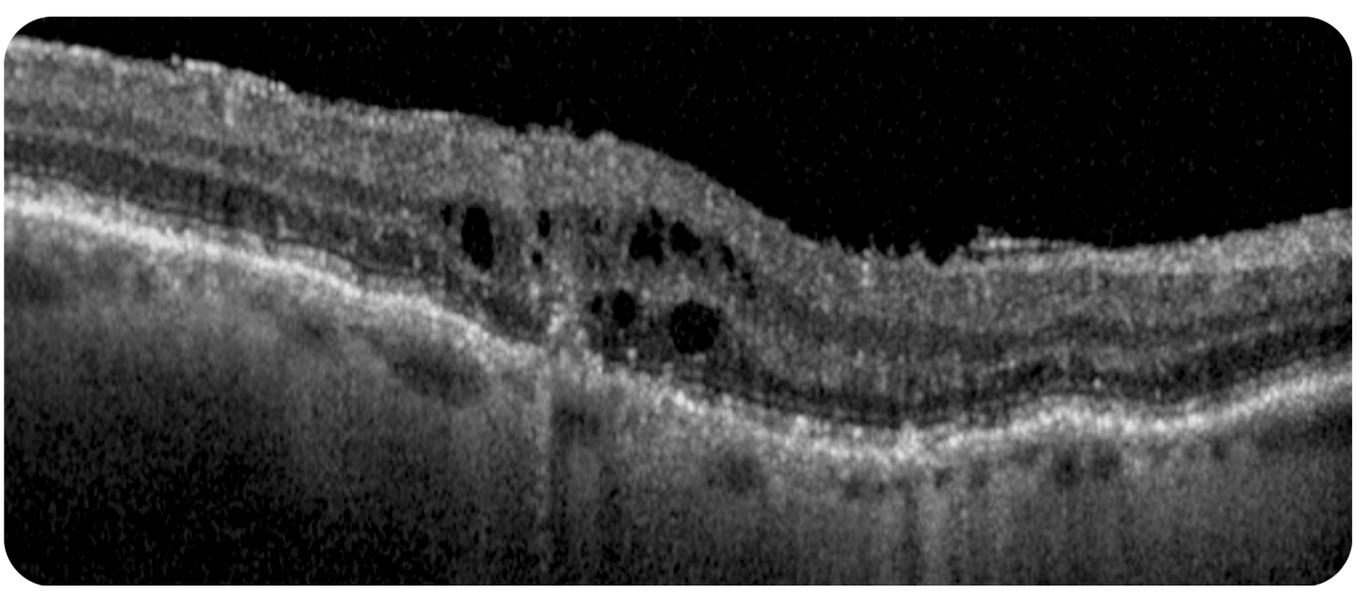
Age 68



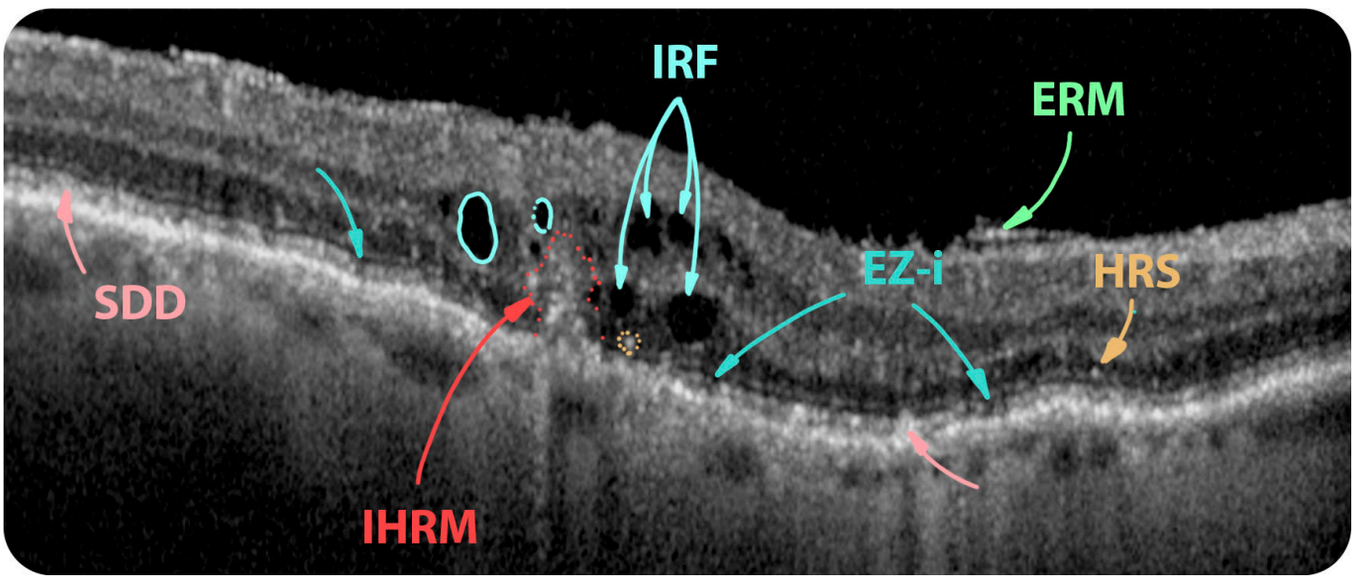
IR Image:
Irregular appearance of the entire fundus with large areas with reticular pseudodrusen mainly in the peripheral macula.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 42



Findings

Area	Alteration	Description
Subretinal	RPE	Irregular
	SDD	Subretinal drusenoid deposits
	PR	EZ fragmented
Intraretinal	IHRM	Medium reflectivity, fuzzy
	IRF	Widespread, associated to IHRM
	HRS	Different entities
Epiretinal	ERM	Thin

Interpretation

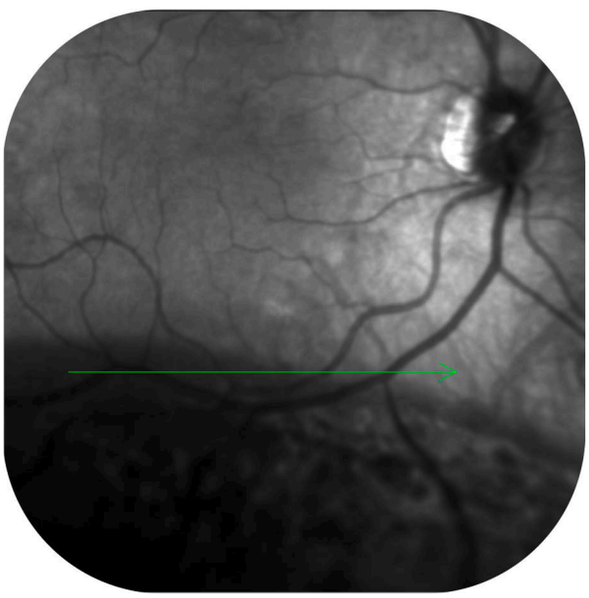
Multiple SDD (a hallmark of **AMD**), most notably seen in the IR image, represent a risk factor for type 3 MNV. The accumulation of fuzzy-looking IHRM and associated IRF, is consistent with an **active type 3 MNV**. Additionally, there are multiple points of EZ interruption and a thin ERM is present.

RPE: Retinal Pigment Epithelium – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptor – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **IHRM**: Intraretinal Hyperreflective Material – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization – **AMD:** Age-related Macular Degeneration

Case 43

Case 43

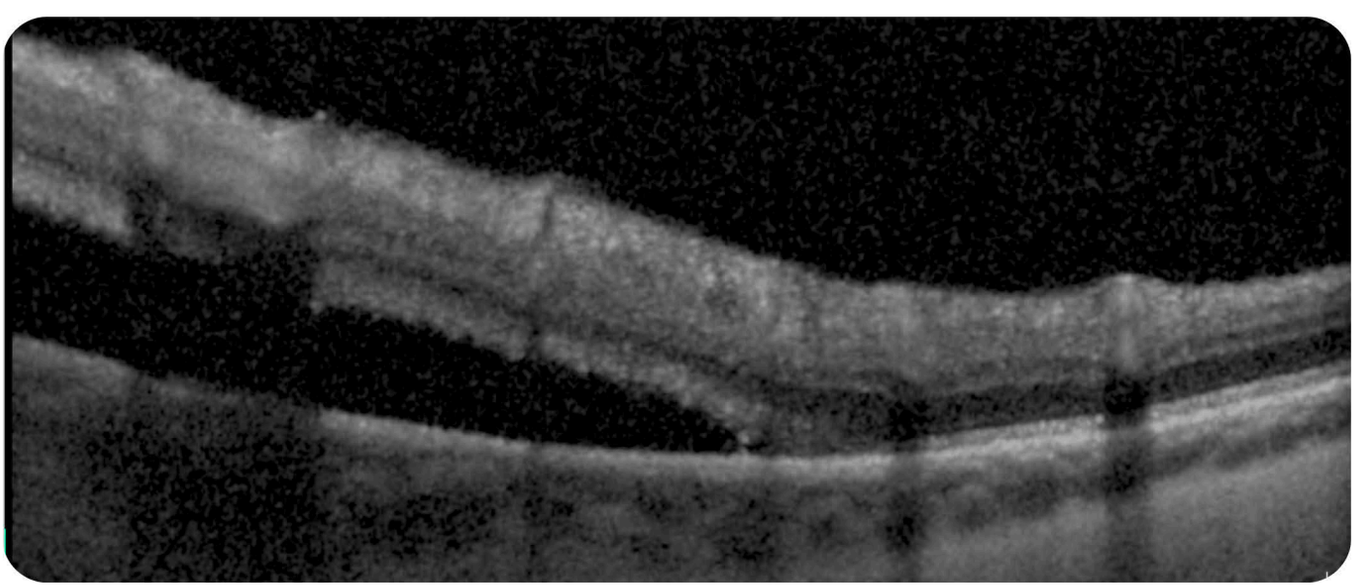
Age 57



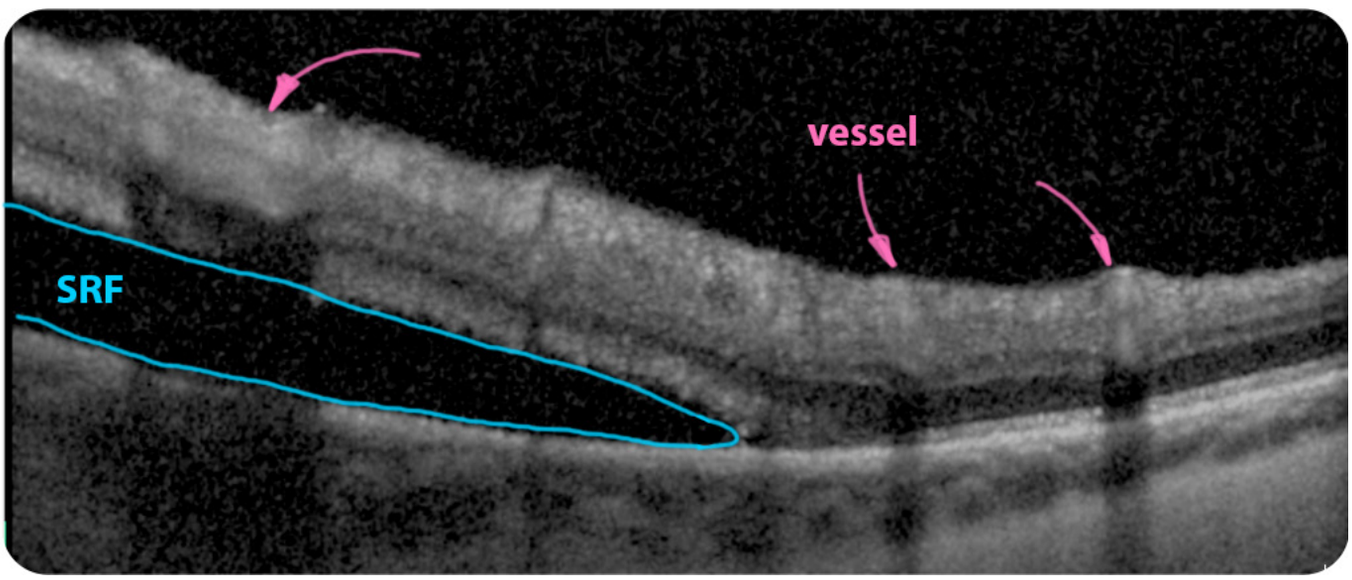
IR Image:
Extensive and dark curtain-shaped alteration to the inferior and inferotemporal arcades.

Scan Quality:
Good with no artifacts

Location:
Extramacular



Case 43



Findings

Area	Alteration	Description
Subretinal	SRF	Retinal detachment

Interpretation

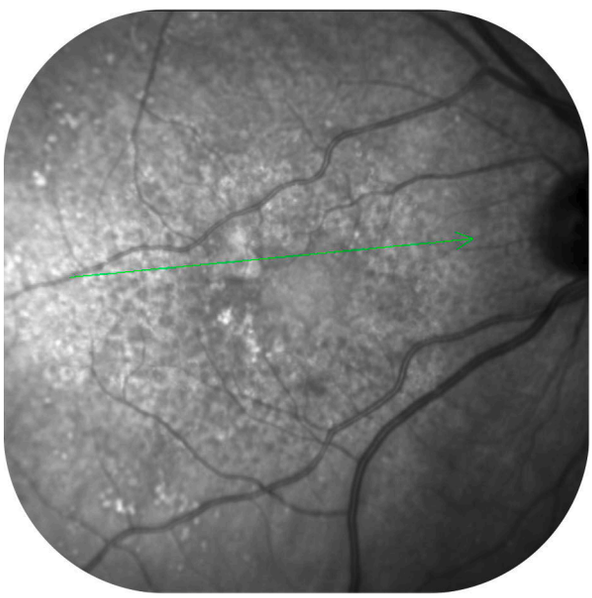
A macula-on retinal detachment is visible in the IR image. The cross-sectional scan confirms the subretinal fluid accumulation without further subretinal or preretinal alterations.

SRF: Subretinal Fluid

Case 44

Case 44

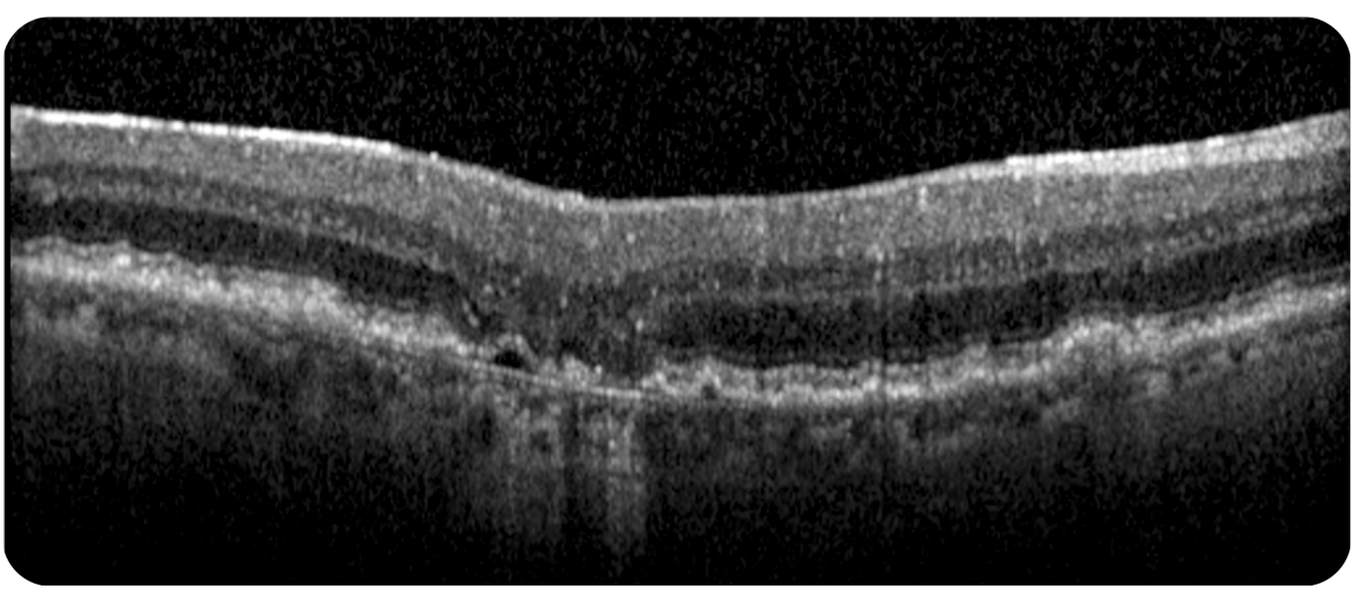
Age 84



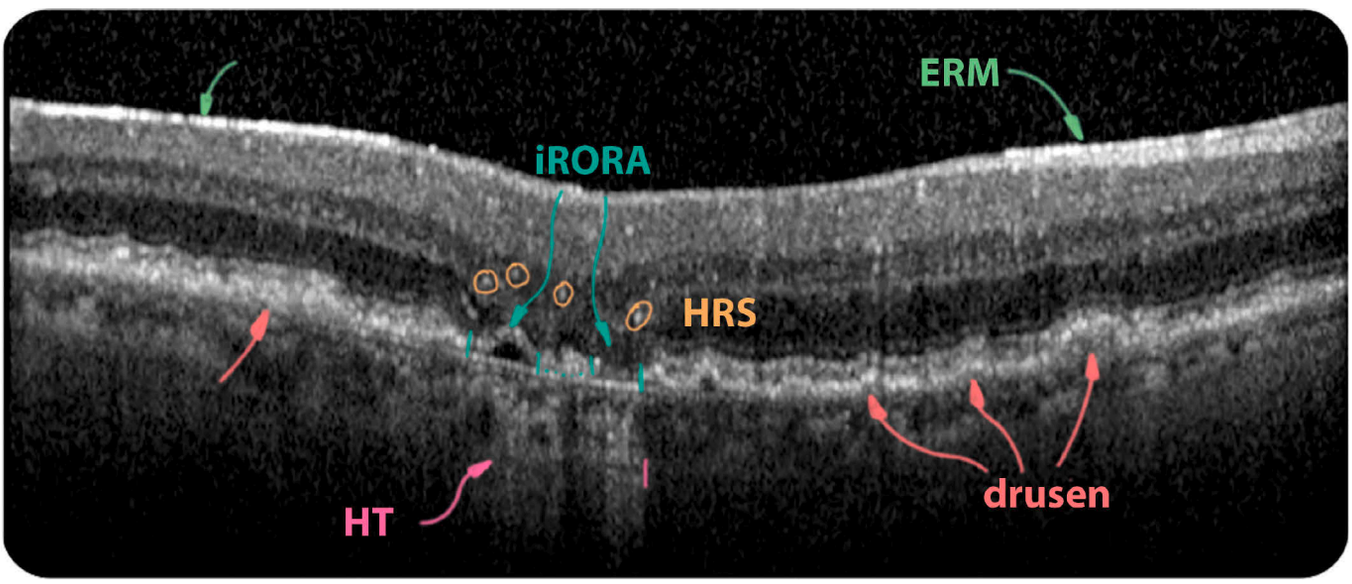
IR Image:
There is a gross irregular appearance of the macular region with noted drusen and pseudodrusen.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 44



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, interrupted
	PED	Multiple drusen
	Atrophy	iRORA
Subretinal	PR	PR atrophy
Intraretinal	HRS	Associated to PR atrophy
Preretinal	ERM	Thin

Interpretation

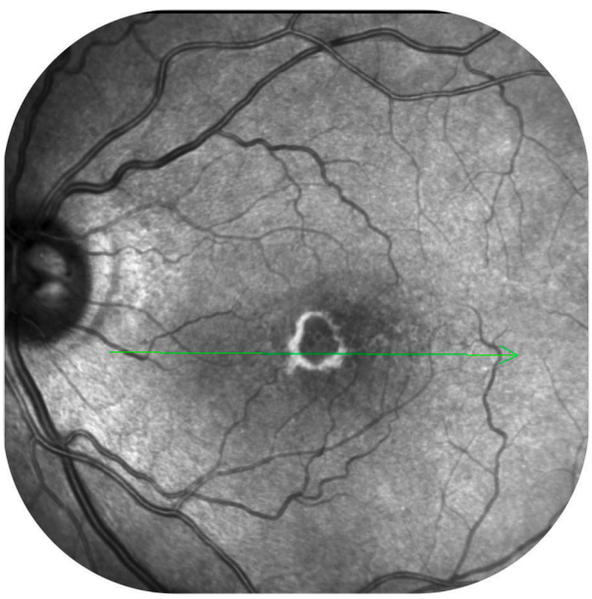
In this scan, we can see multiple drusen and an area of incomplete RPE and PR atrophy (iRORA). Right above the area of atrophy is an accumulation of HRS, likely representing degenerated retinal tissue or macrophages engulfing it. This patient very likely suffers from **GA secondary to AMD (iRORA)**. Additionally, there is a thin ERM.

RPE: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **iRORA**: Incomplete RPE and Outer Retinal Atrophy – **GA**: Geographic Atrophy – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **HT:** Hypertransmission – **AMD:** Age-related Macular Degeneration

Case 45

Case 45

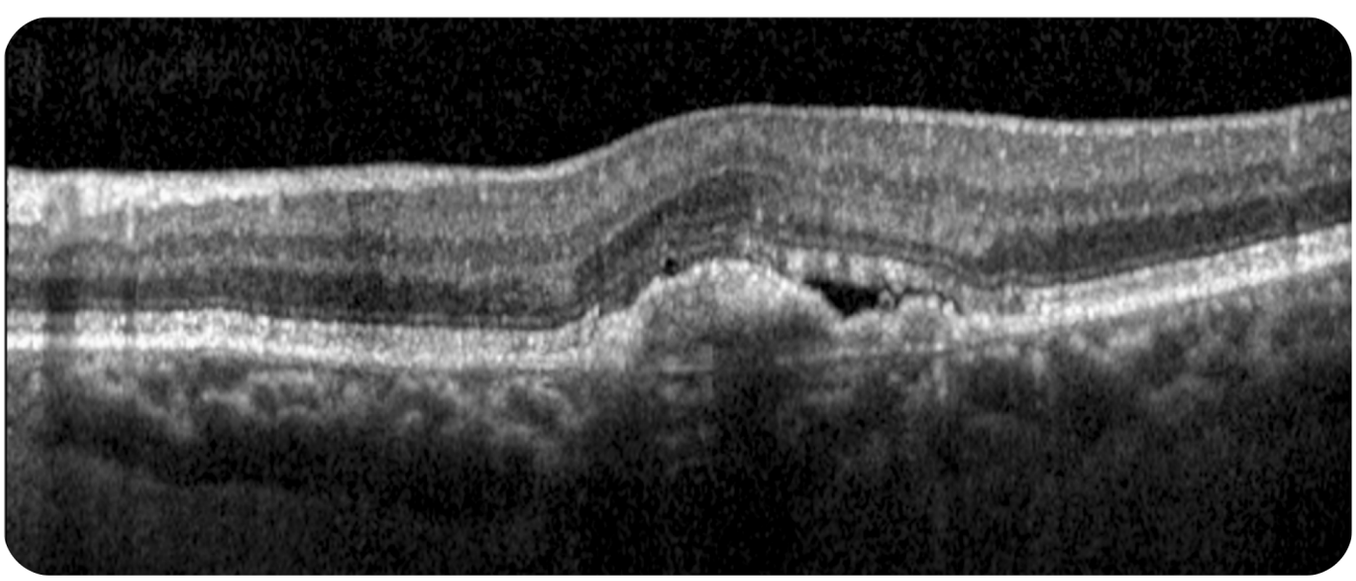
Age 78



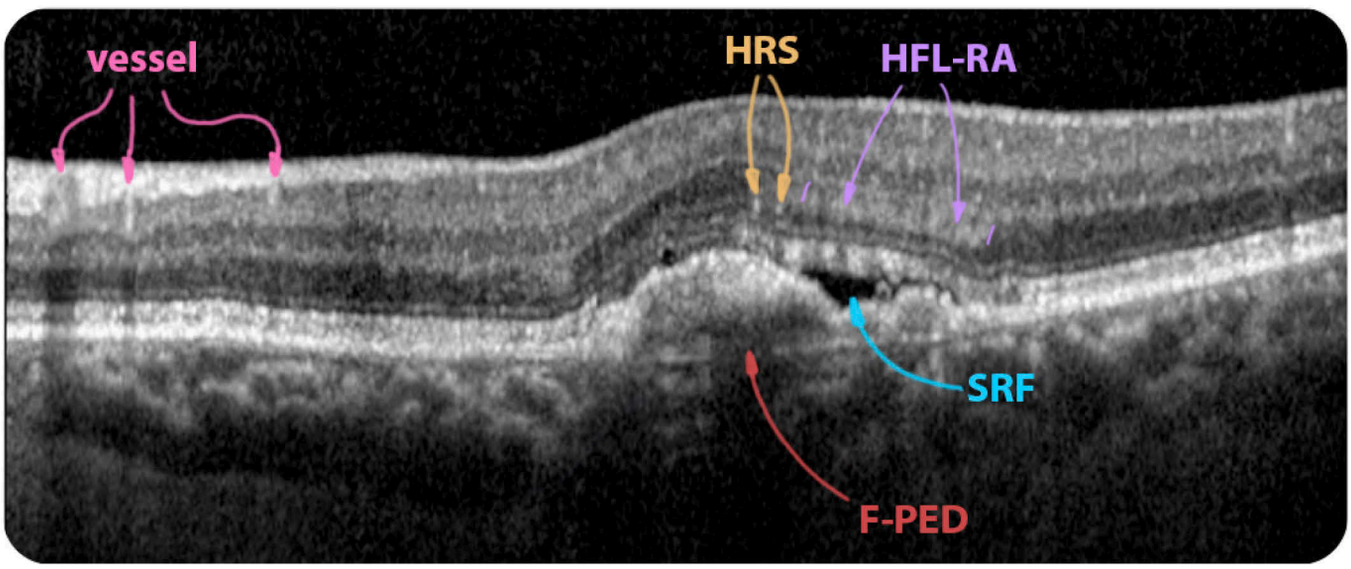
IR Image:
Large hyperreflective ring encompassing a hyporeflective area through the macula.

Scan Quality:
Good with no artifacts

Location:
Parafoveal



Case 45



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	PED	Fibrovascular PED with associated SRF
Subretinal	SRF	Due to exudation
Intraretinal	HRS	Outer retina

Interpretation

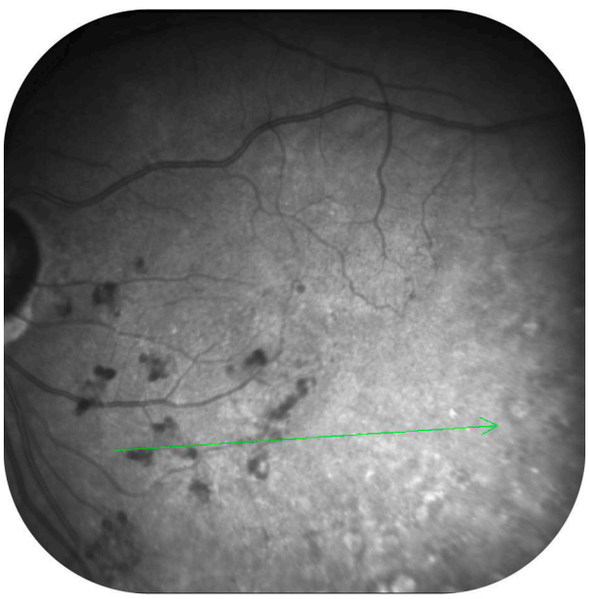
A large fibrovascular PED with associated SRF is a finding very consistent with **an active type 1 MNV**. The internal reflectivity of the PED is altered, with the right hemisphere presenting signal blockage, which could be due to subretinal hemorrhage. The EZ is interrupted and the HRS are located around the ELM and could be a sign of PR degeneration. The increased reflectivity of the ONL over the SRF very likely represents a Henle fiber layer - reflex artifact (HFL-RA).

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **SRF**: Subretinal Fluid – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization – **EZ**: Ellipsoid Zone – **ELM**: External Limiting Membrane – **ONL**: Outer Nuclear Layer – **HFL-RA:** Henle Fiber Layer – Reflex Artifact – **PR:** Photoreceptor

Case 46

Case 46

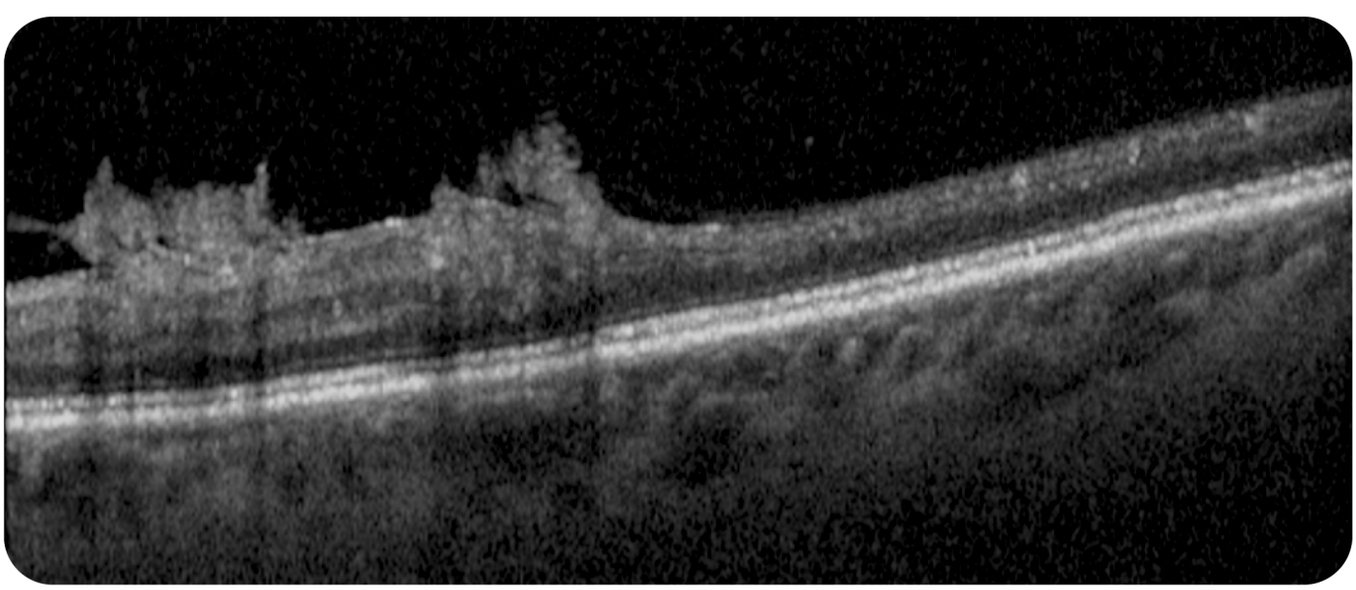
Age 68



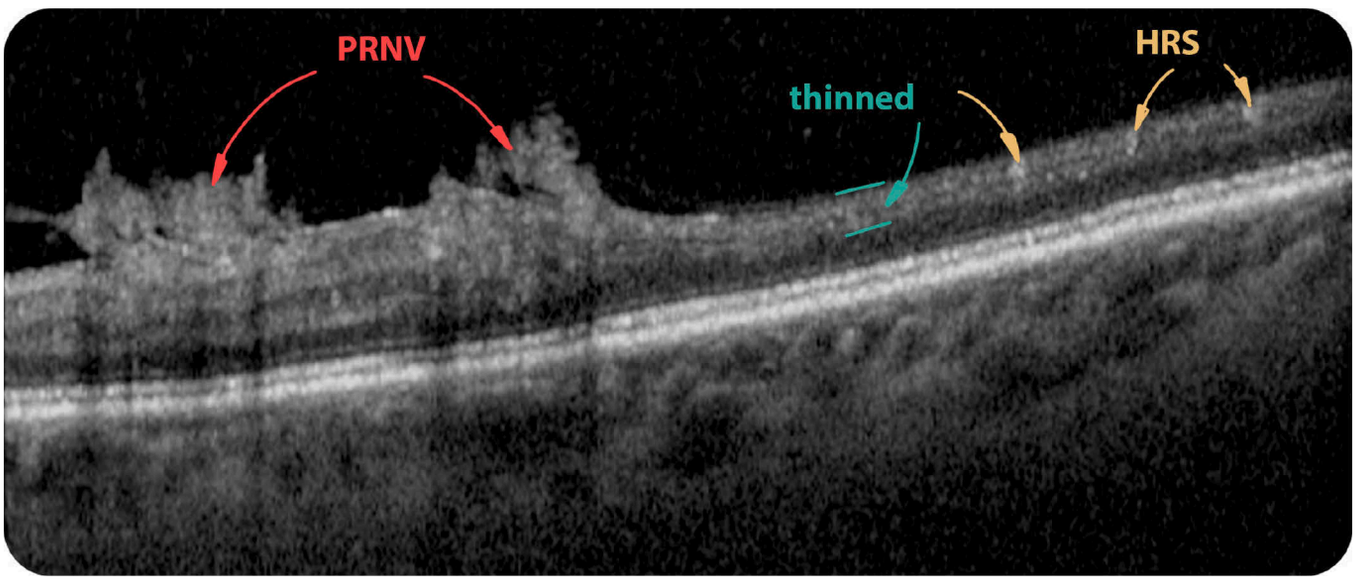
IR Image:
The inferior temporal quadrant has an irregular appearance with missing retinal vessels. There are multiple grape-like, irregular, hyporeflective alterations.

Scan Quality:
Good with no artifacts

Location:
Perifovea



Case 46



Findings

Area	Alteration	Description
Intraretinal	HRS	Inner retina
	IRL	Thinning of inner retinal layers
Preretinal	PRNV	Preretinal neovascularisation

Interpretation

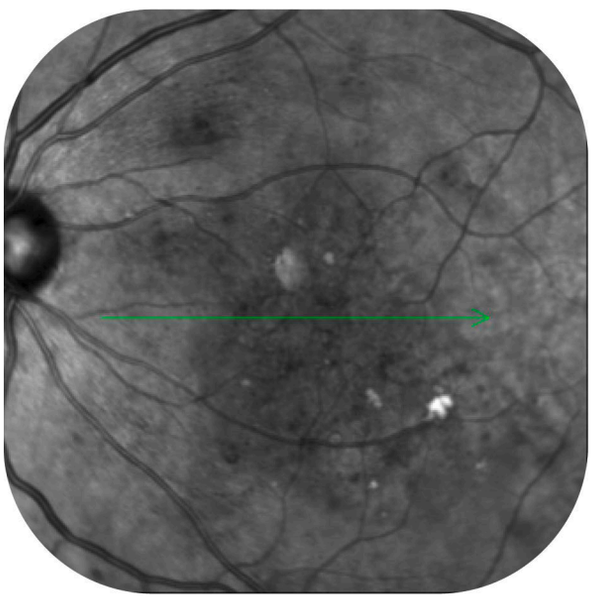
This patient presents atrophic inner retinal layers on the right half of the scan, indicating a past ischemic event. On the left side of the scan, there is some medium reflective material in the epi-/preretinal area, which is highly suspicious of preretinal neovascularization. Therefore, this patient is likely suffering from **secondary preretinal neovascularization after retinal ischemia**. The HRS could represent either extravasated lipids or degenerated retinal tissue.

HRS: Hyperreflective Spots – **IRL**: Inner Retinal Layers – **PRNV**: Preretinal Neovascularization

Case 47

Case 47

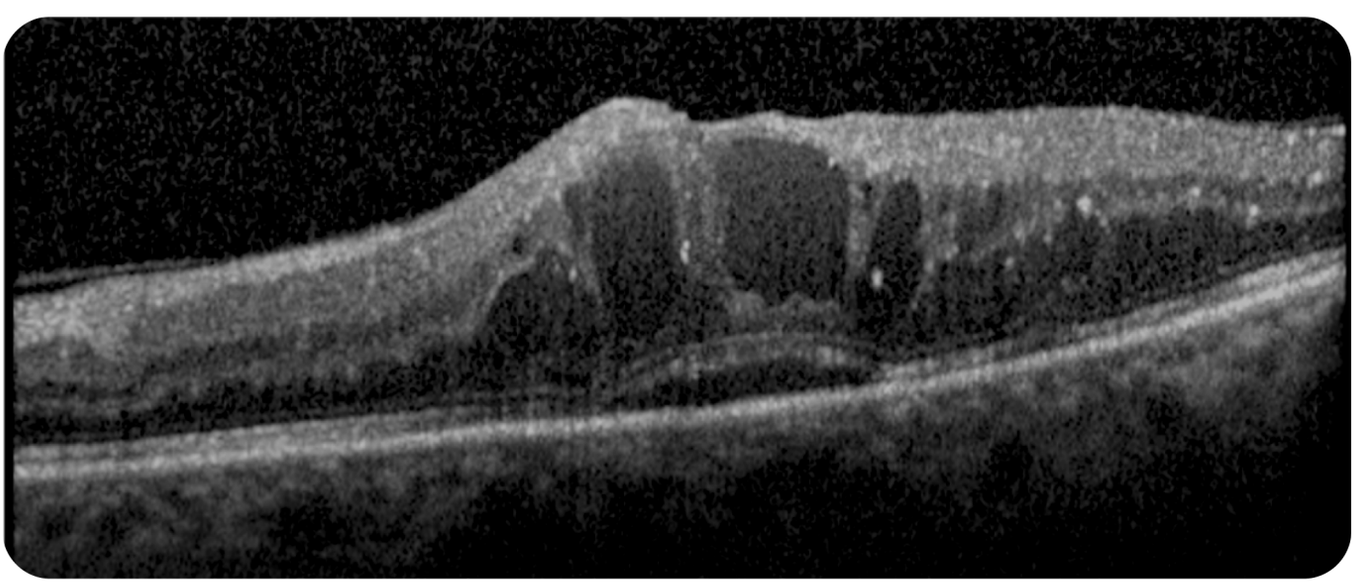
Age 63



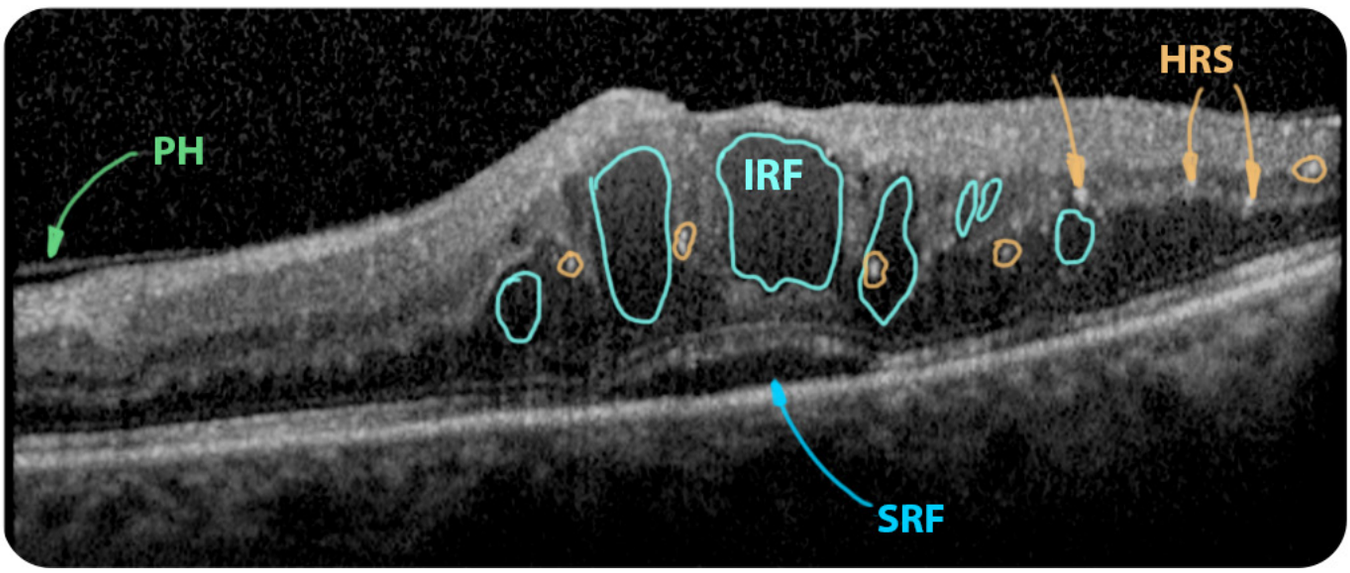
IR Image:
Multiple bright and dark spots – consistent with exudates and retinal hemorrhages, respectively; large hyporeflective area consistent with fluid accumulation

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 47



Findings

Area	Alteration	Description
Subretinal	SRF	Correlated to CME
Intraretinal	IRF	Causing retinal thickening
	HRS	Predominantly around the OPL
Preretinal	PH	Posterior hyaloid

Interpretation

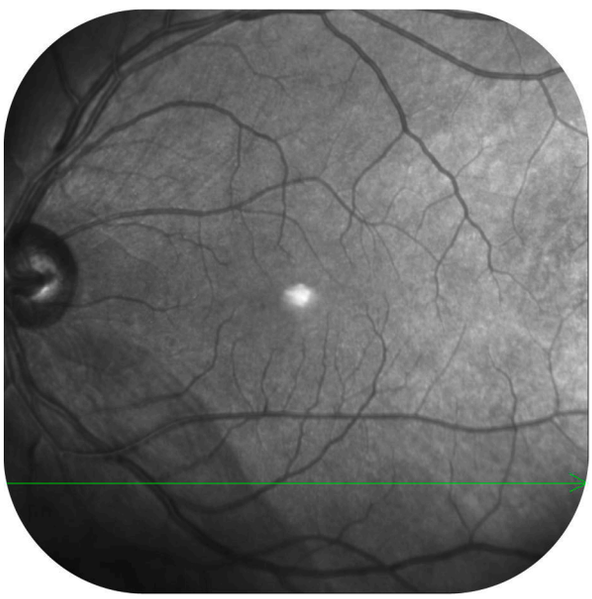
This patient has multiple fluid-filled spaces resulting in a thickening of the retina (CME) and SRF accumulation associated with the CME. The HRS around the OPL most likely represent exudate, indicating a retinal vascular disease and in conjunction with the findings in the IR Image (hard exudates and hemorrhages) this patient is very likely suffering from a **diabetic macular edema**. Additionally, the posterior hyaloid is visible in this scan.

SRF Subretinal Fluid – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **OPL**: Outer Plexiform Layer – **PH**: Posterior Hyaloid – **CME:** Cystoid Macular Edema

Case 48

Case 48

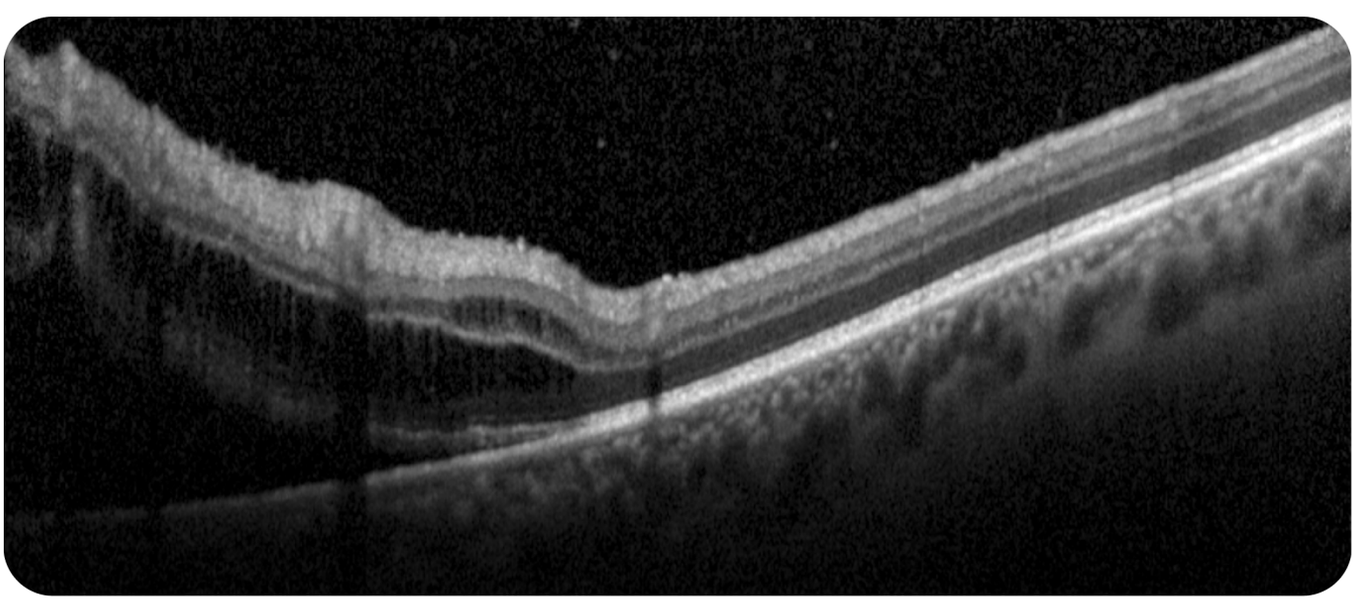
Age 55



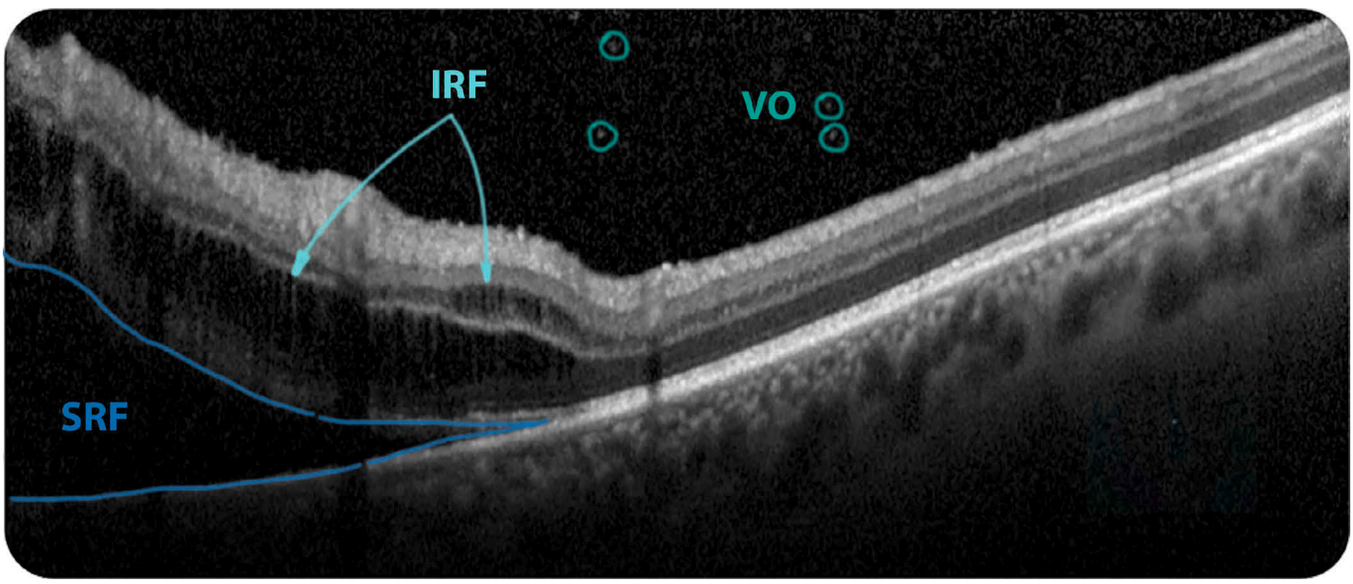
IR Image:
The inferior left quadrant presents a demarcated hyporeflective zone.

Scan Quality:
Good with no artifacts

Location:
Inferior arcade



Case 48



Findings

Area	Alteration	Description
Subretinal	SRF	Widespread SRF accumulation
Intraretinal	IRF	Causing retinal thickening
Preretinal	Vitreous	Multiple tiny HRS

Interpretation

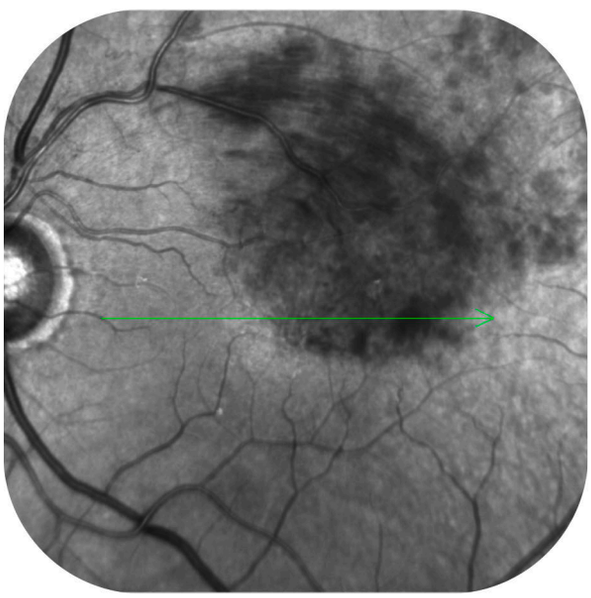
On the left side of the scan, the retina is detached from the RPE, and there is a large space with SRF. In addition, the detachment is associated with a widespread accumulation of IRF that results in diffuse retinal edema. In conjunction with the IR image, we can confidently diagnose a **retinal detachment**. The HRS in the vitreous could represent blood secondary to a retinal tear.

SRF: Subretinal Fluid – **IRF:** Intraretinal Fluid – **HRS:** Hyperreflective Spots – **RPE:** Retinal Pigment Epithelium – **VO:** Vitreous Opacity

Case 49

Case 49

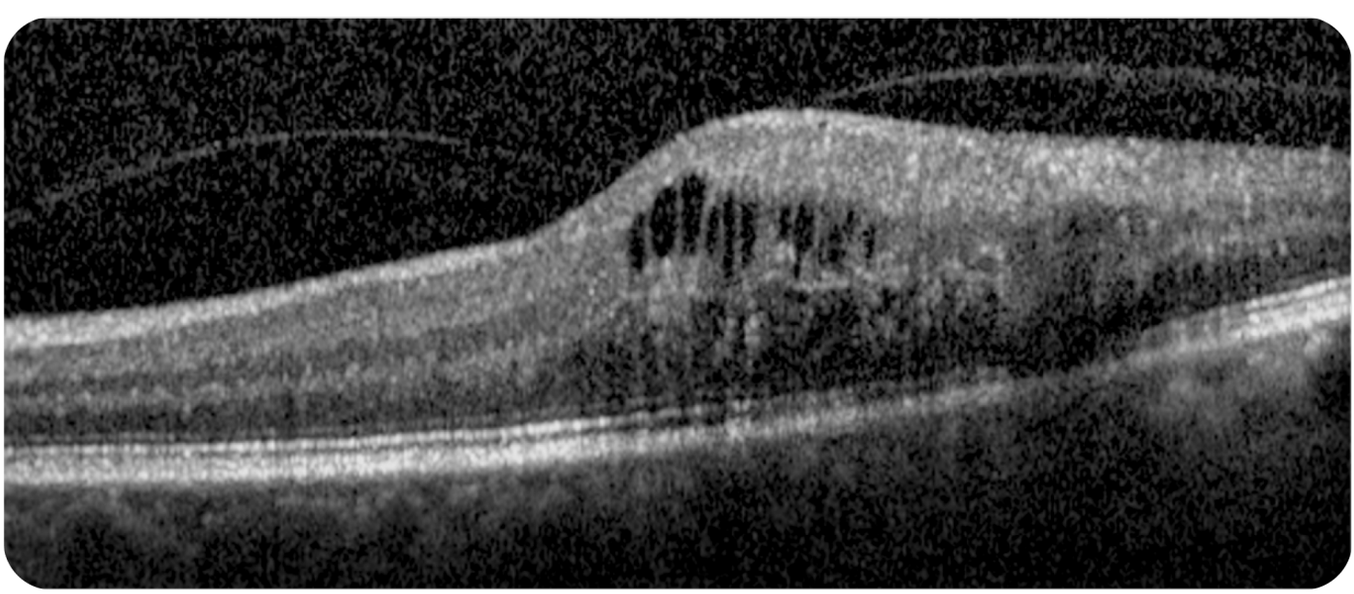
Age 54



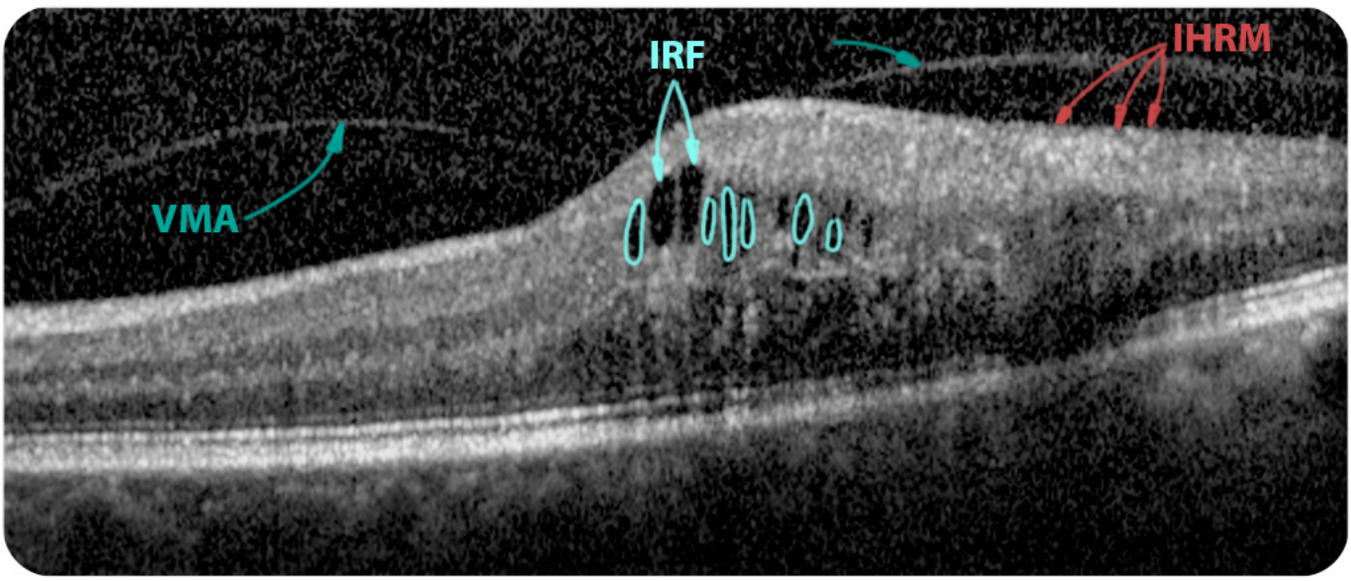
IR Image:
Large hyporeflective area reaching from the superior vascular arcade to the fovea.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 49



Findings

Area	Alteration	Description
Intraretinal	IRF	Causing retinal thickening
	IHRM	Intraretinal haemorrhage
Preretinal	VMA	Vitreomacular adhesion

Interpretation

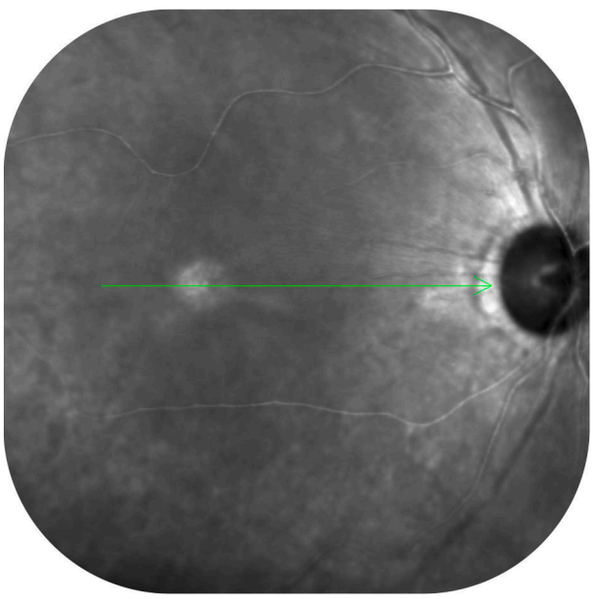
The IRF is causing a retinal thickening and results in a CME. In addition, there is an accumulation of IHRM in the inner retinal layers, causing posterior signal blockage – a finding consistent with intraretinal hemorrhage (dark area in the IR image). The IR image presents a picture consistent with a BRVO – so, we are looking at an eye with a **CME secondary to a BRVO.**

IRF: Intraretinal Fluid – **IHRM**: Intraretinal Hyperreflective Material – **VMA**: Vitreomacular Adhesion – **CME**: Cystoid Macular Edema – **BRVO**: Branch Retinal Vein Occlusion

Case 50

Case 50

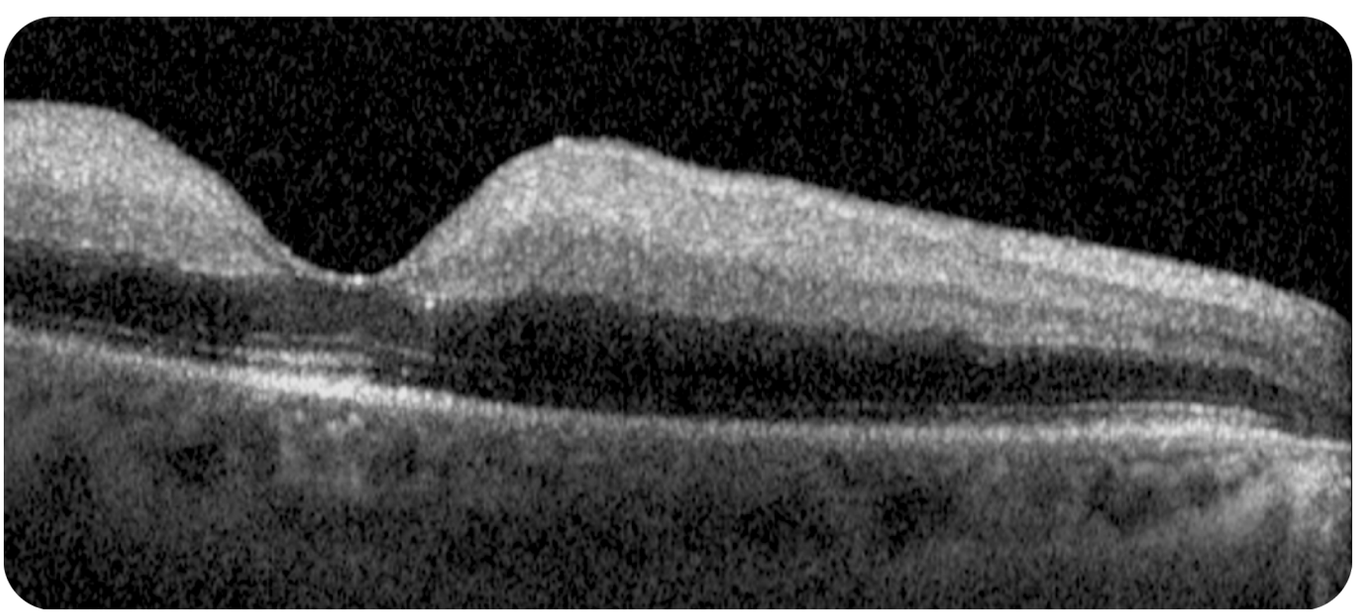
Age 72



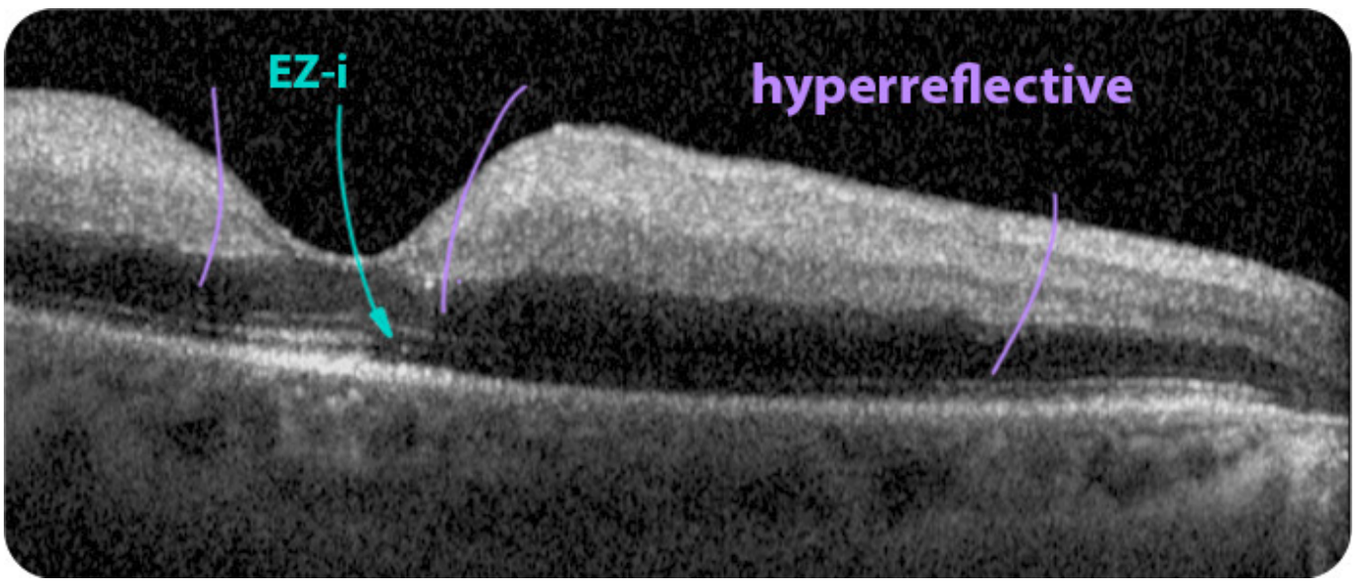
IR Image:
Diffusely blurred IR image. The arteries are thin, and the fovea shines bright in the center of the image.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 50



Findings

Area	Alteration	Description
Intraretinal	PR	EZ interrupted
	IRL	Hyperreflective inner retinal layers

Interpretation

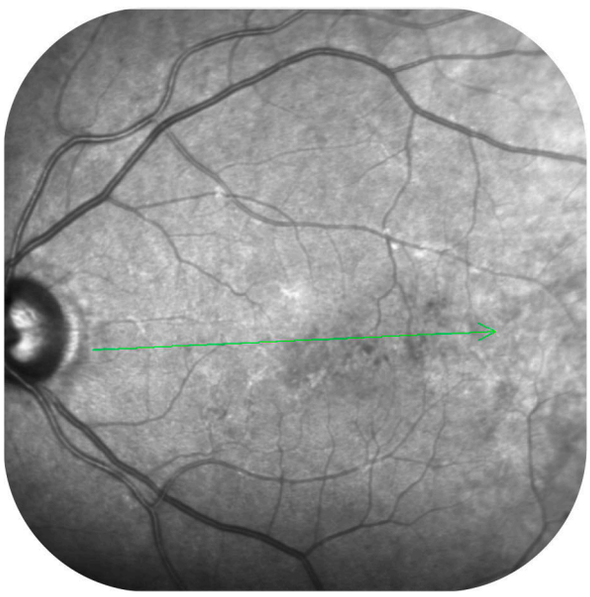
The inner retinal layers appear hyperreflective and diffusely swollen, causing posterior signal blockage. These findings represent intracellular edema, secondary to an ischemic event. The fovea appears brighter, which in conjunction with the hyperreflective inner retinal layers, is a common finding in eyes with **a central retinal artery occlusion**. Additionally, the EZ is interrupted on the right side of the fovea.

PR: Photoreceptor – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **IRL**: Inner Retinal Layers

Case 51

Case 51

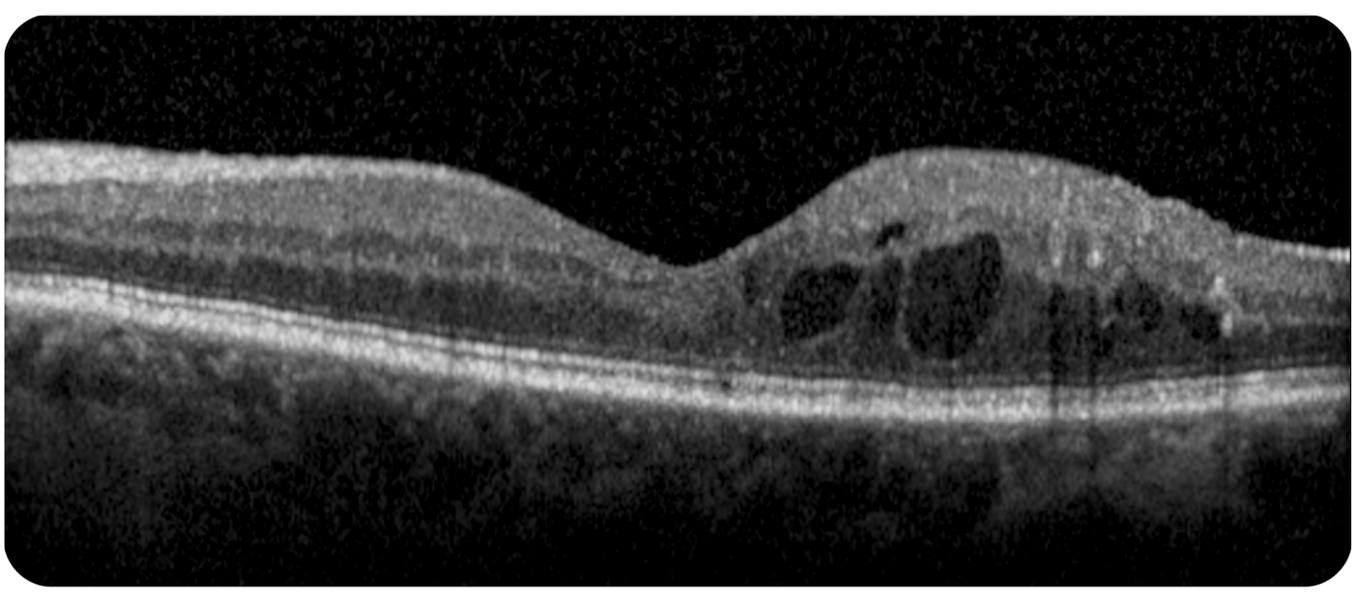
Age 62



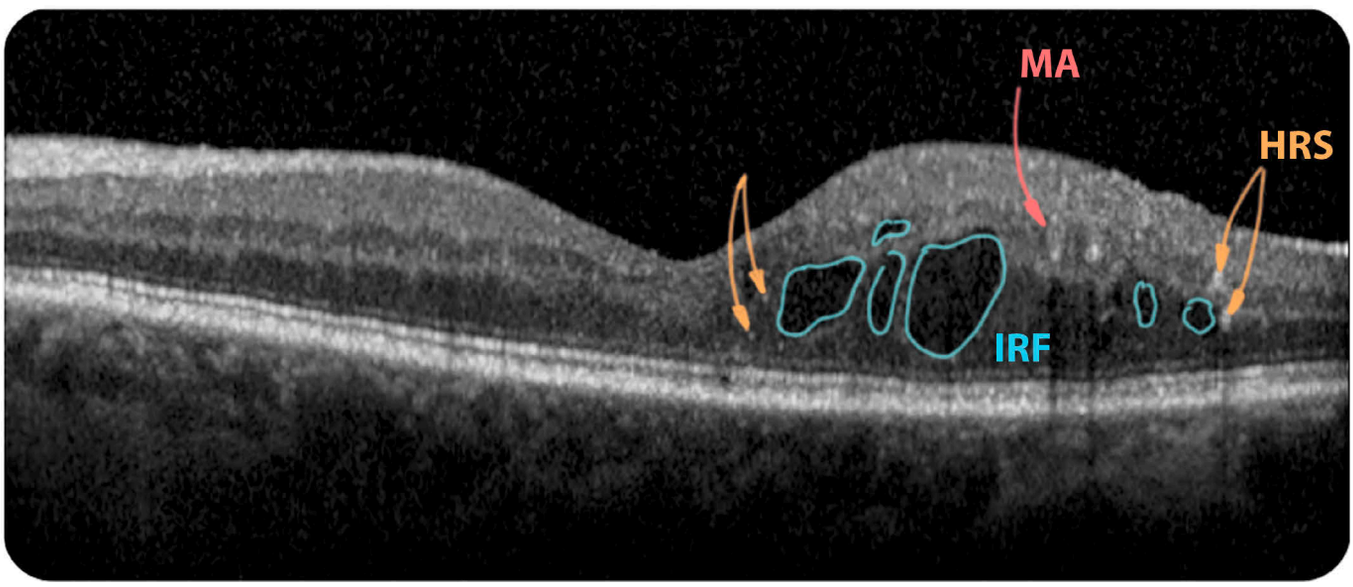
IR Image:
There is a hyporeflective area and concentrated dark spots dispersed around the temporal perifoveal area.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 51



Findings

Area	Alteration	Description
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudates
	IHRM	Microaneurysm

Interpretation

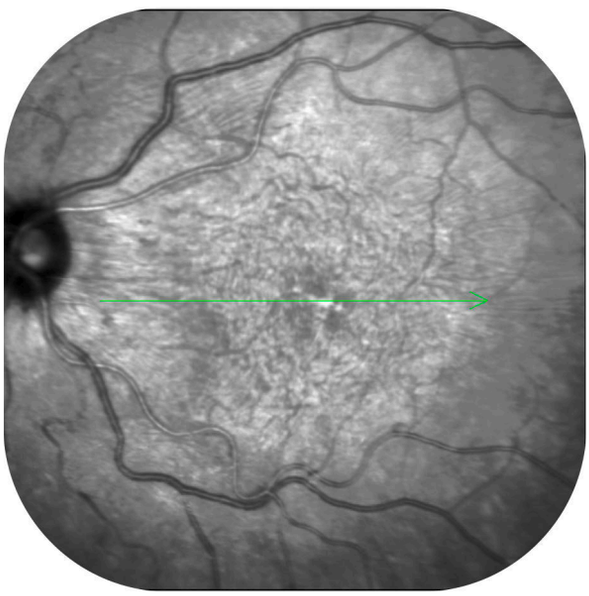
The accumulation of IRF is causing retinal thickening, characteristic of CME. The microaneurysms and lipid exudates are both hallmarks of DR. So, what we are looking at is likely a patient with a **diabetic macular edema**.

IRF: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **IHRM**: Intraretinal Hyperreflective Material – **MA**: Microaneurysm – **DR**: Diabetic Retinopathy – **CME:** Cystoid Macular Edema

Case 52

Case 52

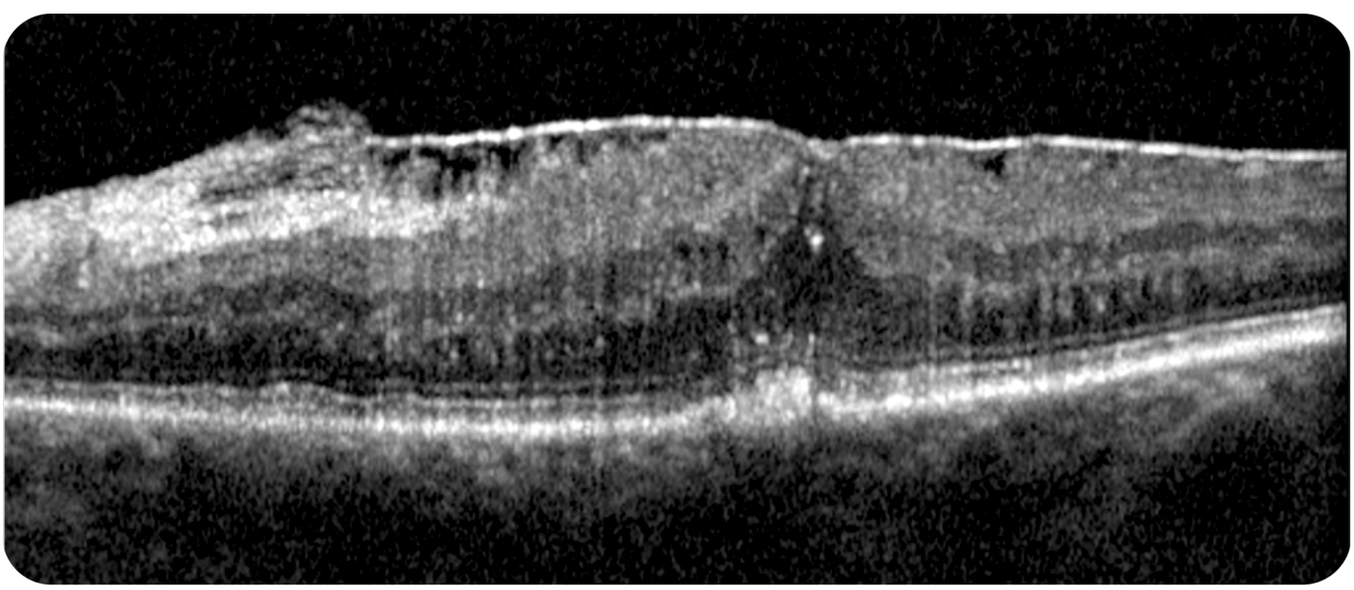
Age 74



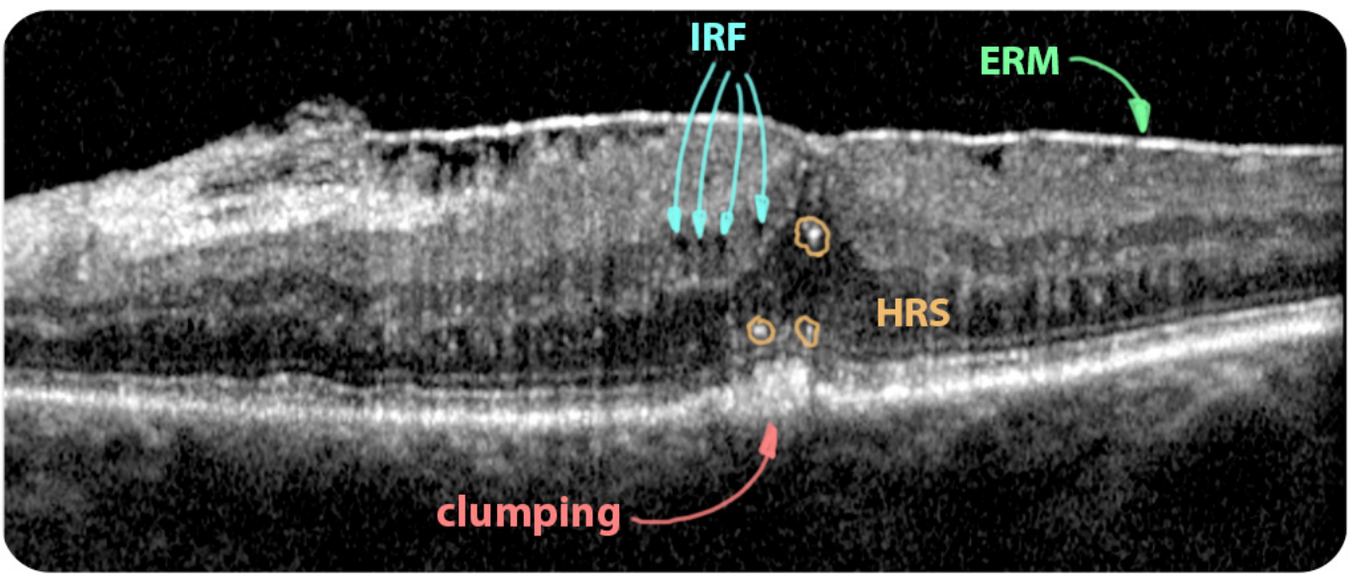
IR Image:
Wrinkling of the retinal surface, irregular appearance, central hyperreflective spot.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 52



Findings

Area	Alteration	Description
Sub-RPE	RPE	Thickened, clumped
Subretinal	PR	ELM interrupted
Intraretinal	IRF	Tractional edema
	HRS	Associated to RPE alteration
Epiretinal	ERM	Loss of foveal contour

Interpretation

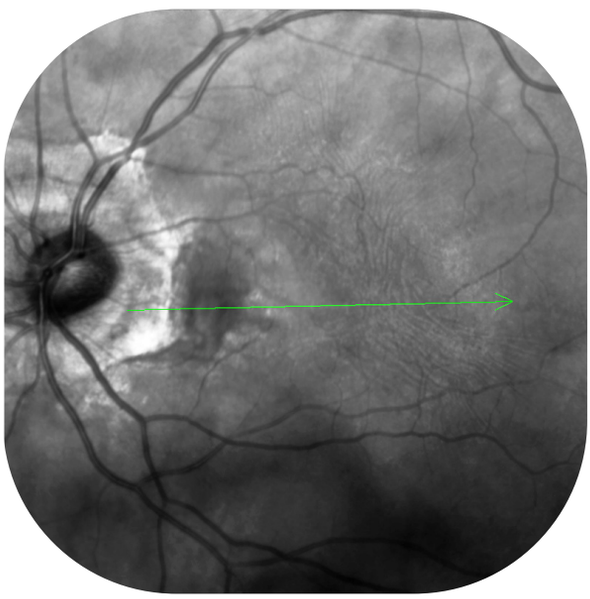
This patient has a thick **ERM** that is causing a mild disorganization of the retinal layers (DRIL), an elevation of the foveal contour and a **tractional edema**. In addition, there is a thickening/clumping of the RPE, right at the fovea, which is associated with pigment migration (HRS). The RNFL looks shattered.

RPE: Retinal Pigment Epithelium – **PR**: Photoreceptor – **ELM**: External Limiting Membrane – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **RNFL**: Retinal Nerve Fiber Layer

Case 53

Case 53

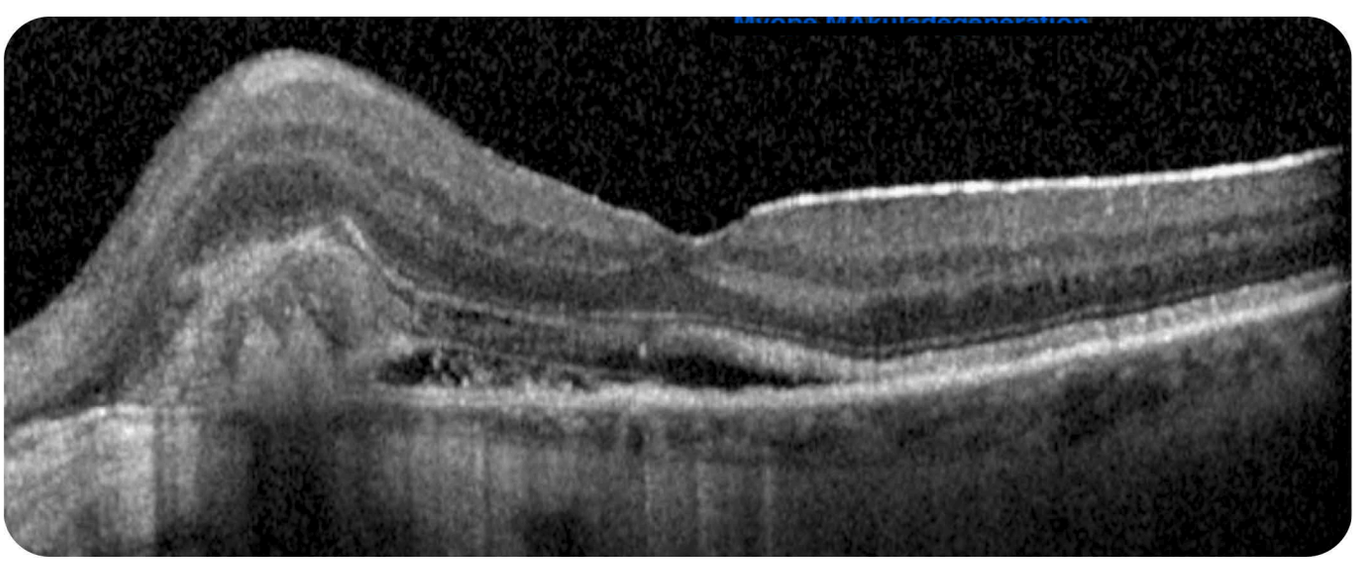
Age 62



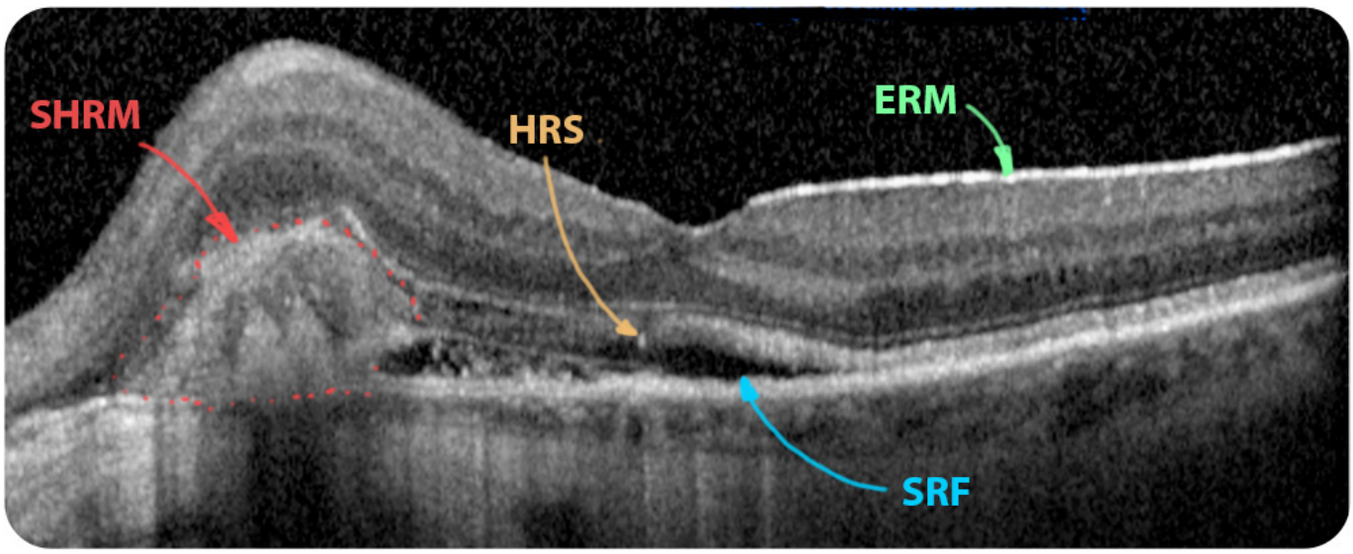
IR Image:
This patient has peripapillary chorioretinal atrophy with an hyporeflective area right next to it; there is wrinkling of the retinal surface indicative of an ERM.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 53



Findings

Area	Alteration	Description
Subretinal	SHRM	Fuzzy with associated SRF
	SRF	Due to exudation from SHRM
	HRS	PR debris
Preretinal	ERM	Epiretinal membrane

Interpretation

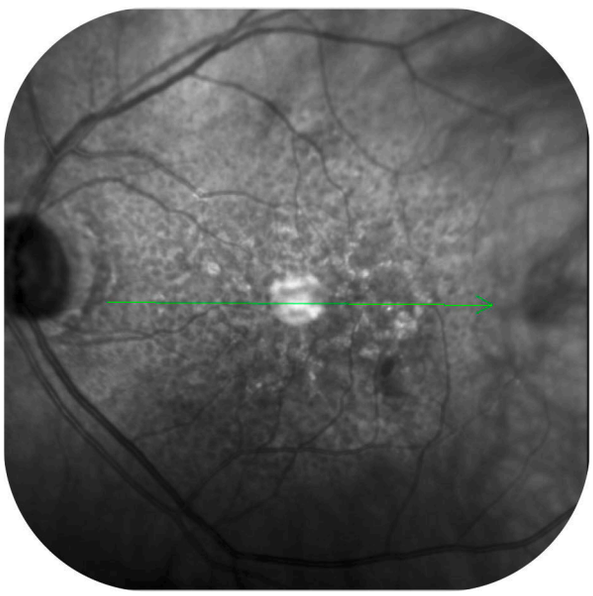
There is a significant accumulation of SHRM with associated SRF. The hyperreflective band underneath the PR could represent a fibrotic membrane and the HRS likely represent cellular debris or engulfing macrophages. Considering the slightly tilted disc and the peripapillary chorioretinal atrophy (IR image) this picture is consistent with an **active type 2 MNV in the setting of myopia**. Additionally, in the preretinal area one can find a temporally pronounced ERM.

SHRM: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **HRS**: Hyperreflective Spots – **PR**: Photoreceptor – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization

Case 54

Case 54

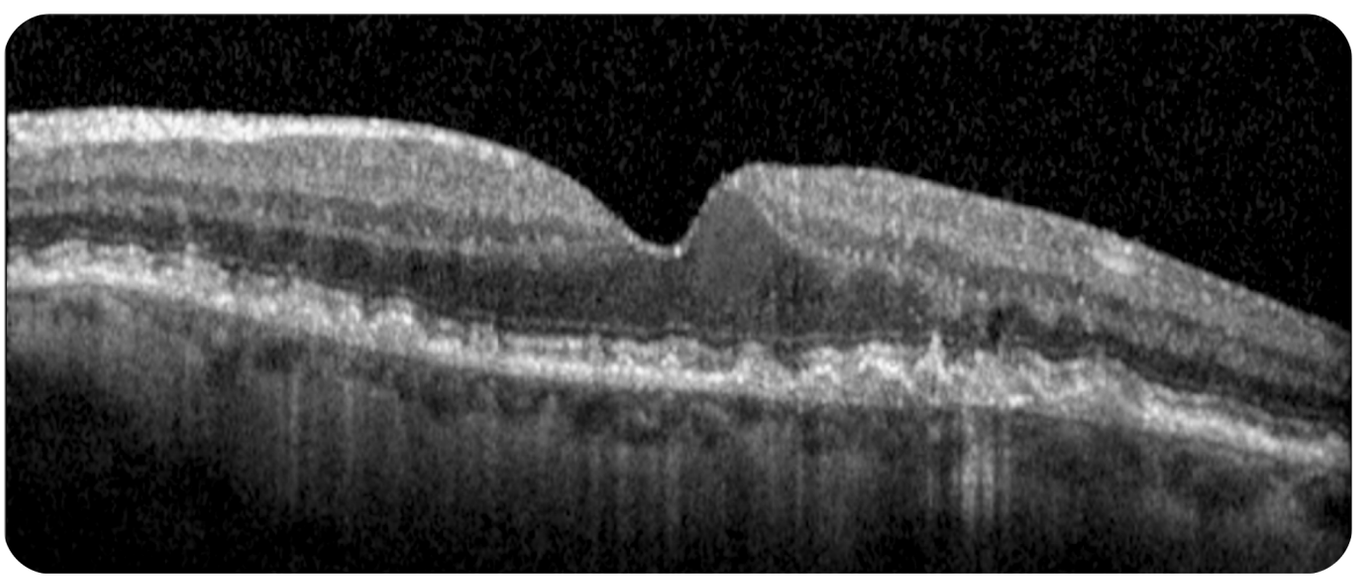
Age 76



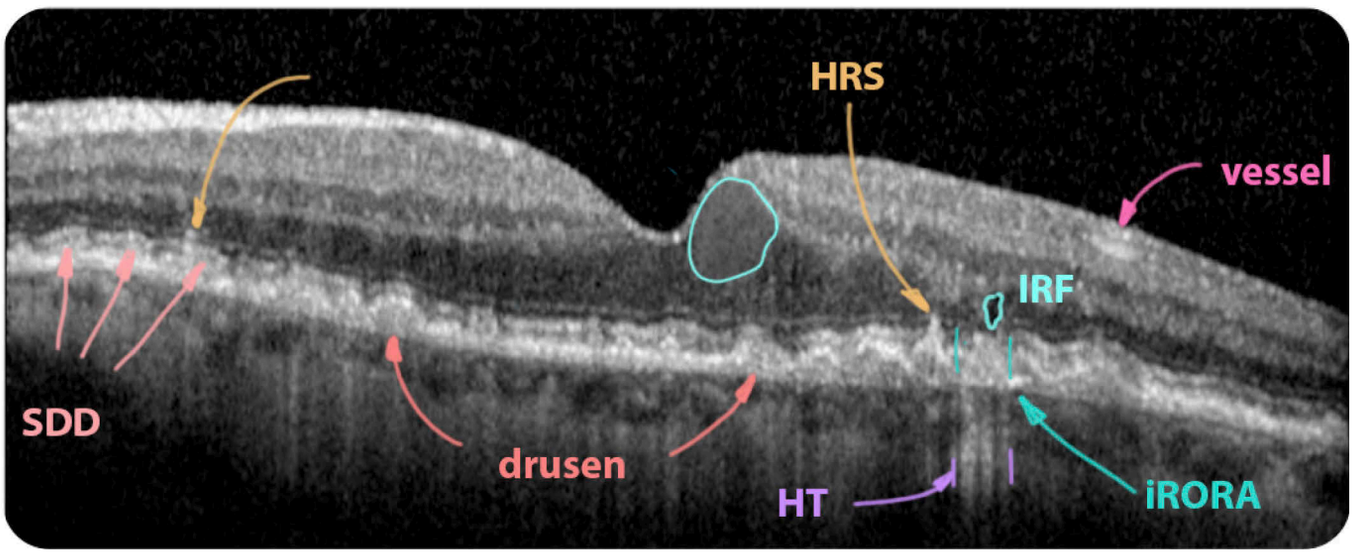
IR Image:
There are large areas of confluent drusen as well as reticular pseudodrusen; a central light-reflex-artifact is present.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 54



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular, interrupted
	PED	Multiple confluent drusen
	Atrophy	iRORA
Subretinal	SDD	Reticular pseudodrusen
	PR	EZ interrupted
Intraretinal	IRF	Local
	HRS	Associated to RPE alteration

Interpretation

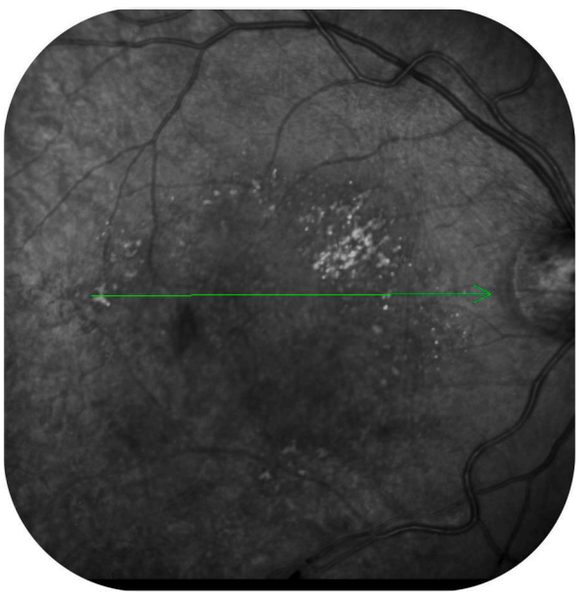
This patient has multiple confluent drusen and subretinal drusenoid deposits. There is a small area of RPE atrophy (iRORA) with adjacent signal hypertransmission and a tiny accumulation of IRF (further fluid must be ruled out on the other scans) Furthermore there is an accumulation of hyporeflective material, which could represent protein-rich fluid right at the fovea. The HRS are associated with PEDs, likely representing pigment migration. This patient has **AMD** and a suspicious exudative process that should be further investigated.

AMD: Age-related Macular Degeneration – **RPE**: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **iRORA**: Incomplete RPE and Outer Retinal Atrophy – **SDD**: Subretinal Drusenoid Deposits – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **HT:** Hypertransmission

Case 55

Case 55

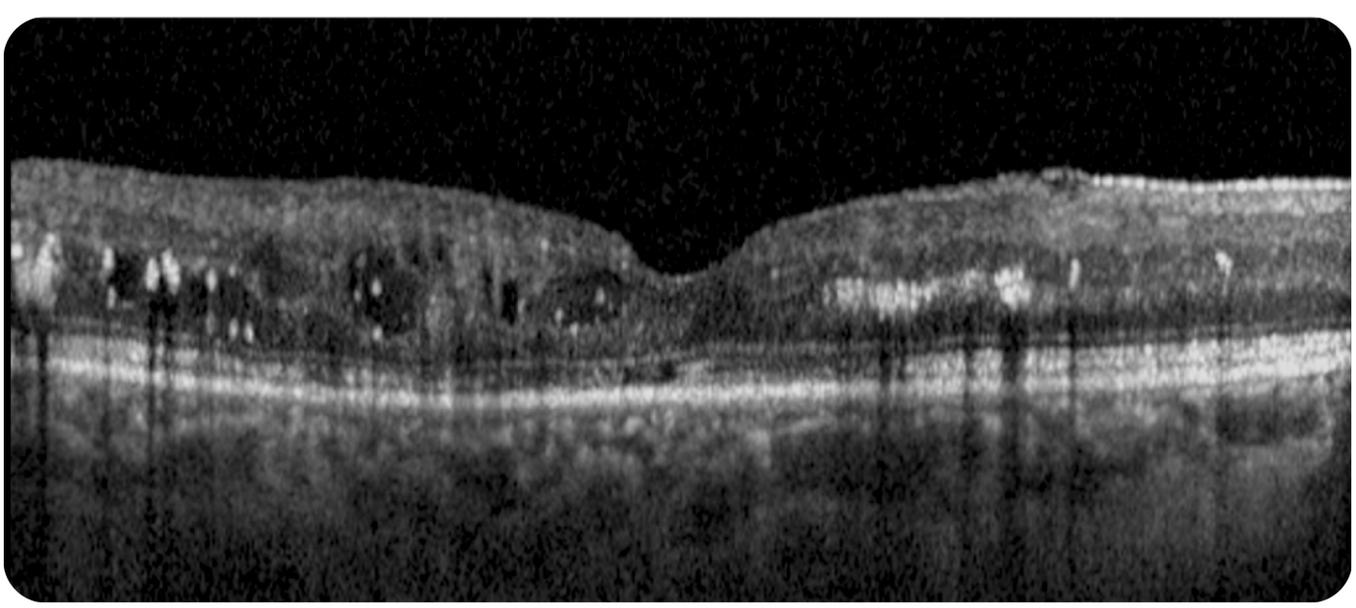
Age 68



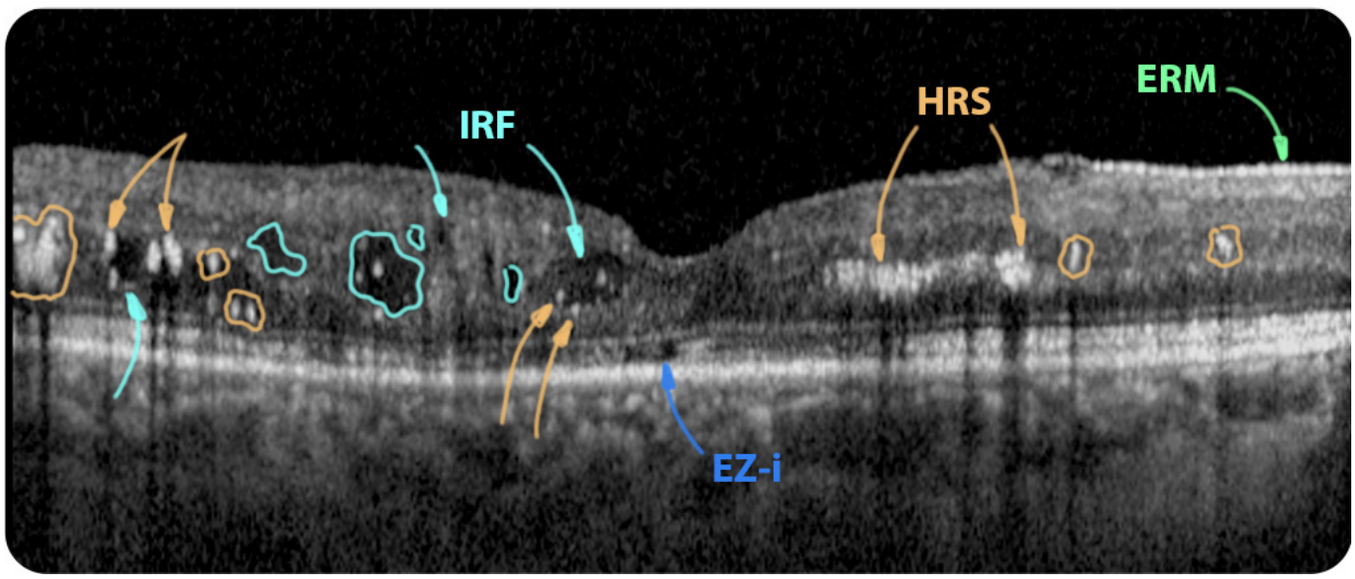
IR Image:
Perifoveal bright spots – consistent with exudate. (circinate figure) The perifoveal area has a darker appearance than the extramacular area.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 55



Findings

Area	Alteration	Description
Sub-retinal	PR	EZ interrupted
Intraretinal	IRF	Widespread
	HRS	Exudate
Preretinal	ERM	Thin

Interpretation

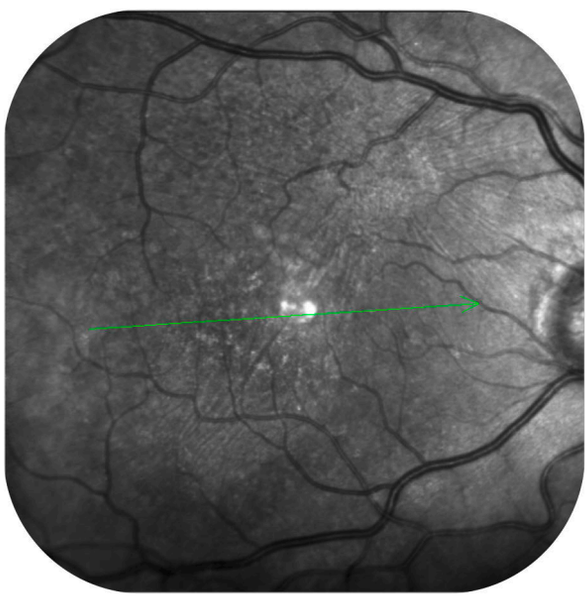
This patient has multiple fluid-filled spaces spread across the scan. Multiple hard exudates indicate a retinal vascular disease, and in addition, the EZ is interrupted right at the fovea, leaving this patient with a comparatively worse visual prognosis. The findings are consistent with **diabetic macular edema.** There is a thin ERM visible on the right side.

PR: Photoreceptor – **EZ**: Ellipsoid Zone – **EZ-i:** Ellipsoid Zone Interruption – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane

Case 56

Case 56

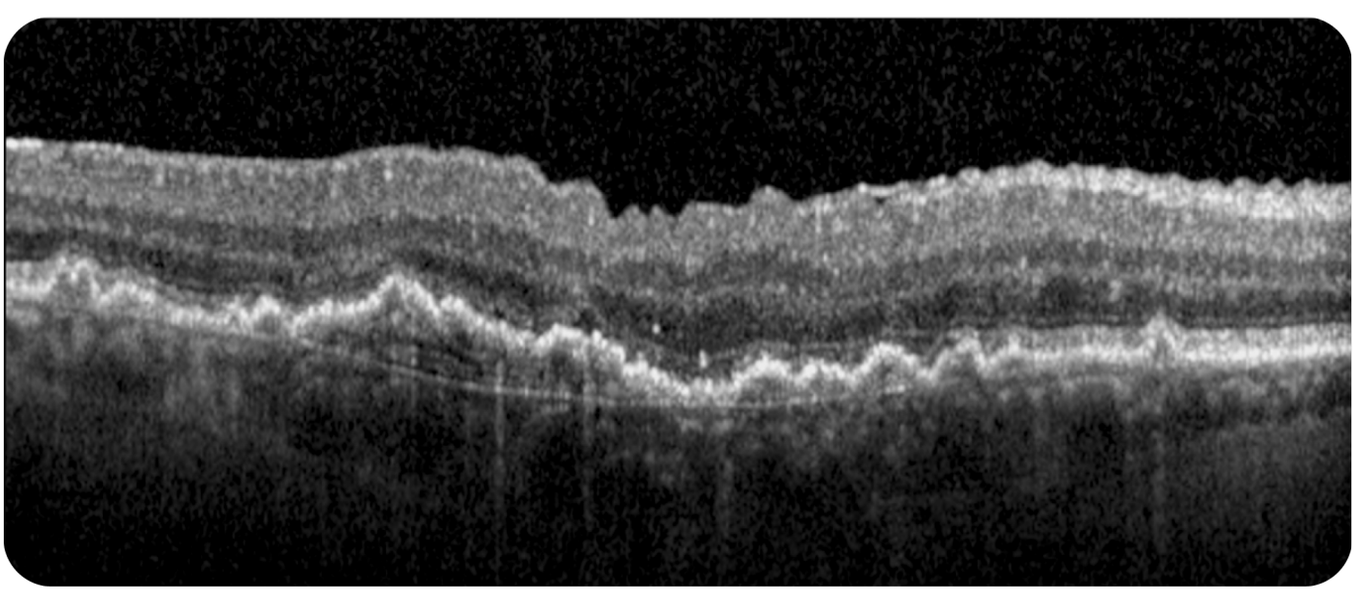
Age 79



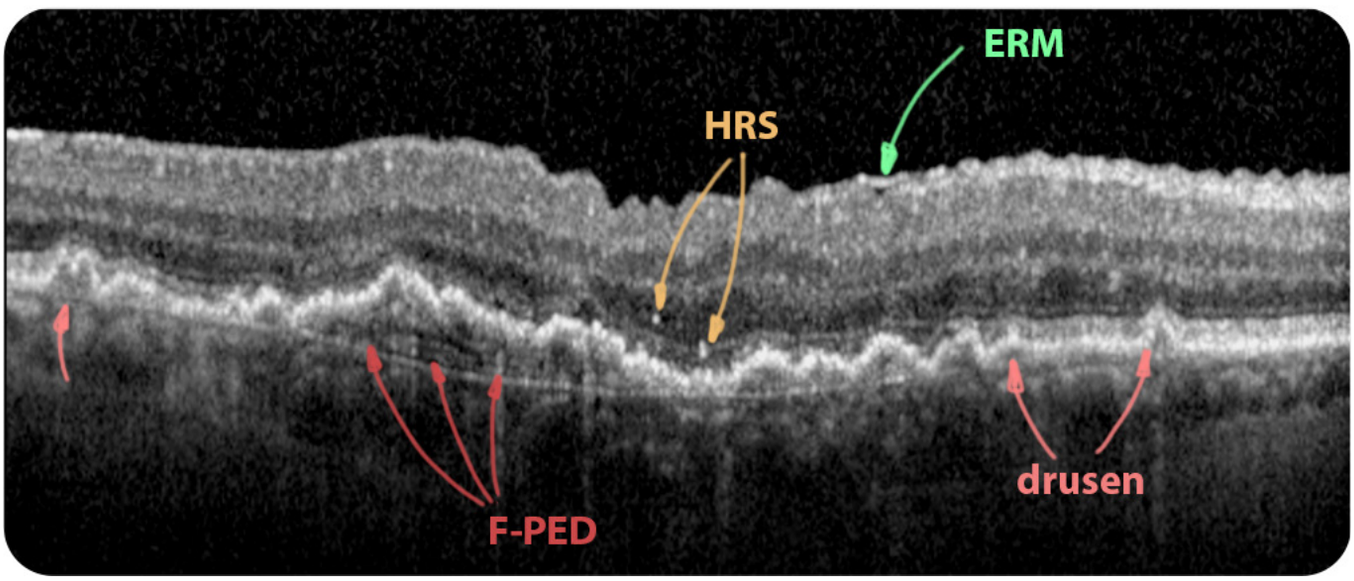
IR Image:
The retinal surface appears wrinkled with two hyperreflective spots and smaller disseminated bright spots scattered centrally.

Scan Quality:
Good with no artifacts

Location:
Periphery



Case 56



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, irregular
	PED	F-PED
Intraretinal	HRS	Outer retina
Preretinal	ERM	Wrinkling of RNFL

Interpretation

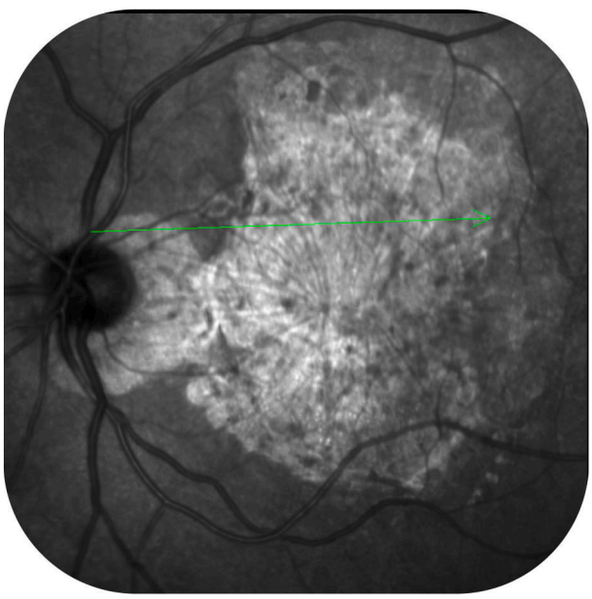
This patient has multiple drusen and a widespread F-PED without significant signs of exudation. In this scan, one can view what could be the cross-section of a neo-vessel within the heterogenous PED. The findings are consistent with a **quiescent type 1 MNV secondary to AMD**. The HRS are associated with RPE alterations and could represent pigment migration. In addition, there is a pronounced ERM that is causing wrinkling of the RNFL.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization – **AMD:** Age-related Macular Degeneration – **RNFL**: Retinal Nerve Fiber Layer

Case 57

Case 57

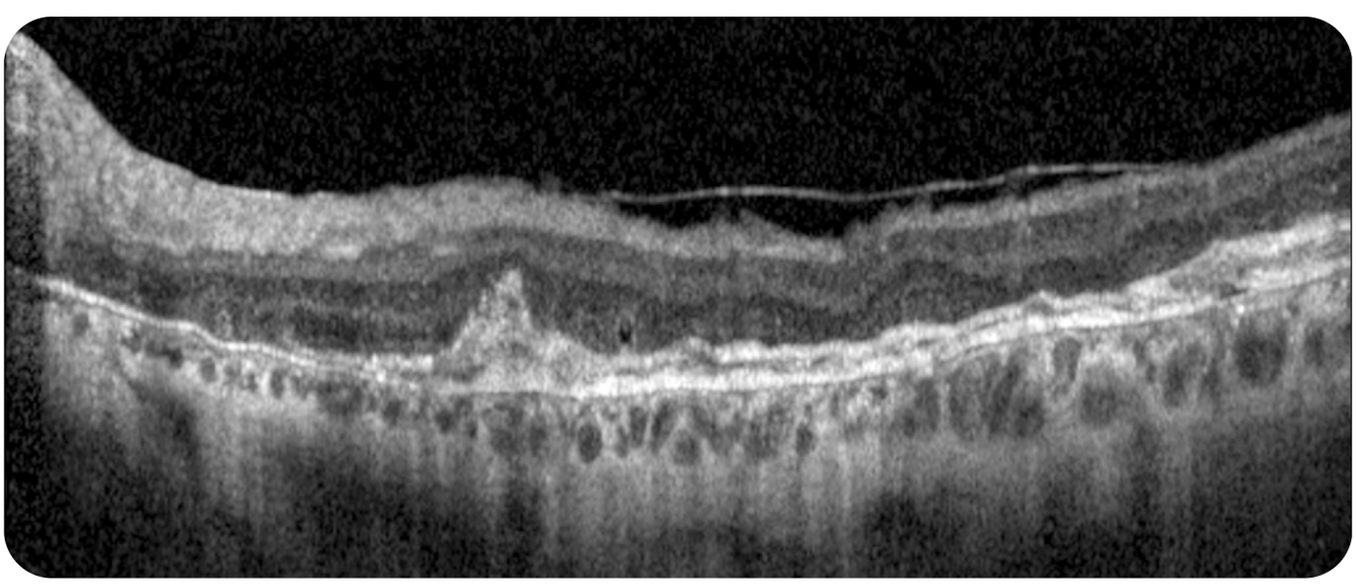
Age 88



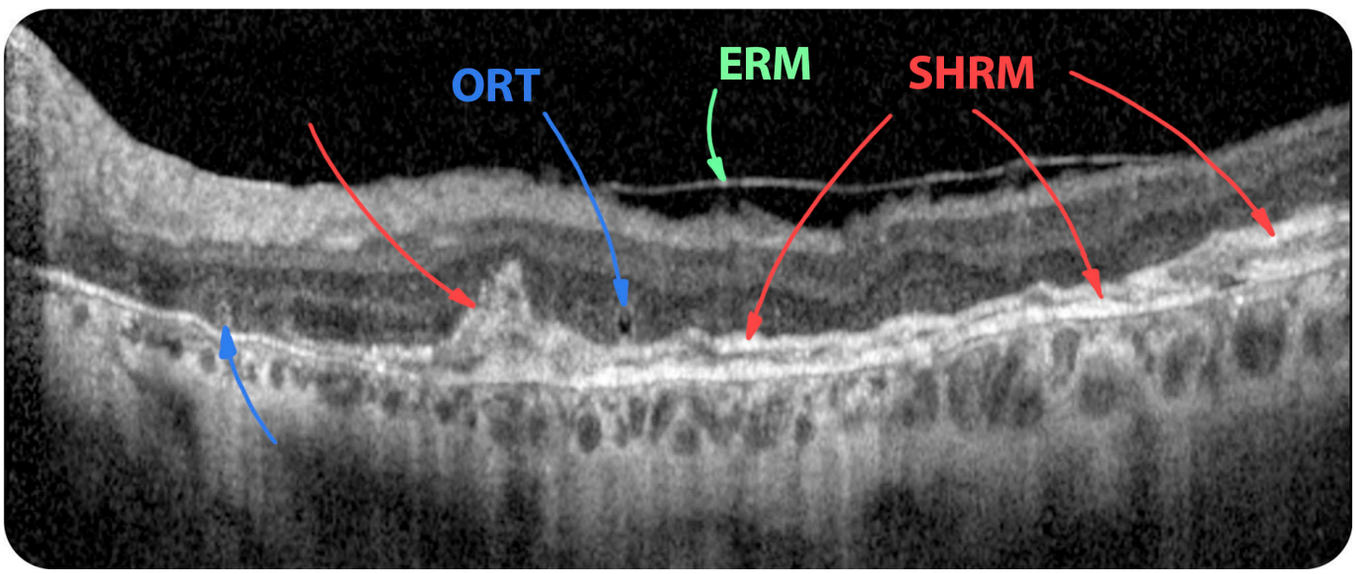
IR Image:
Large hyperreflective area and wrinkled appearance of the entire macula.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 57



Findings

Area	Alteration	Description
Sub-RPE	Choroid	Thinned
Subretinal	RPE	Atrophy
	SHRM	Hyperreflective scar tissue
	PR	EZ and ELM atrophy, ORT
Preretinal	ERM	Epiretinal membrane

Interpretation

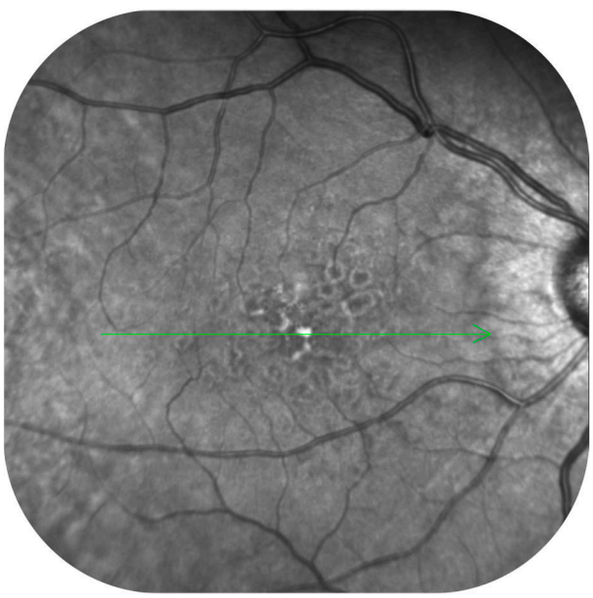
The most striking feature of this eye is the double-layered hyperreflective SHRM, which is very consistent with fibrotic scar tissue. There is no visible EZ or ELM, indicating PR atrophy. Additionally, the ORT represents a rearrangement of the PRs affirming the longevity and stability of the disease. The signal hypertransmission is the result of RPE atrophy. We are looking at a patient with a large **disciform scar**. Additionally, there is an ERM that is only mildly affecting the retinal tissue.

RPE: Retinal Pigment Epithelium – **SHRM**: Subretinal Hyperreflective Material – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **ELM**: External Limiting Membrane – **ORT**: Outer Retinal Tubulation – **ERM**: Epiretinal Membrane

Case 58

Case 58

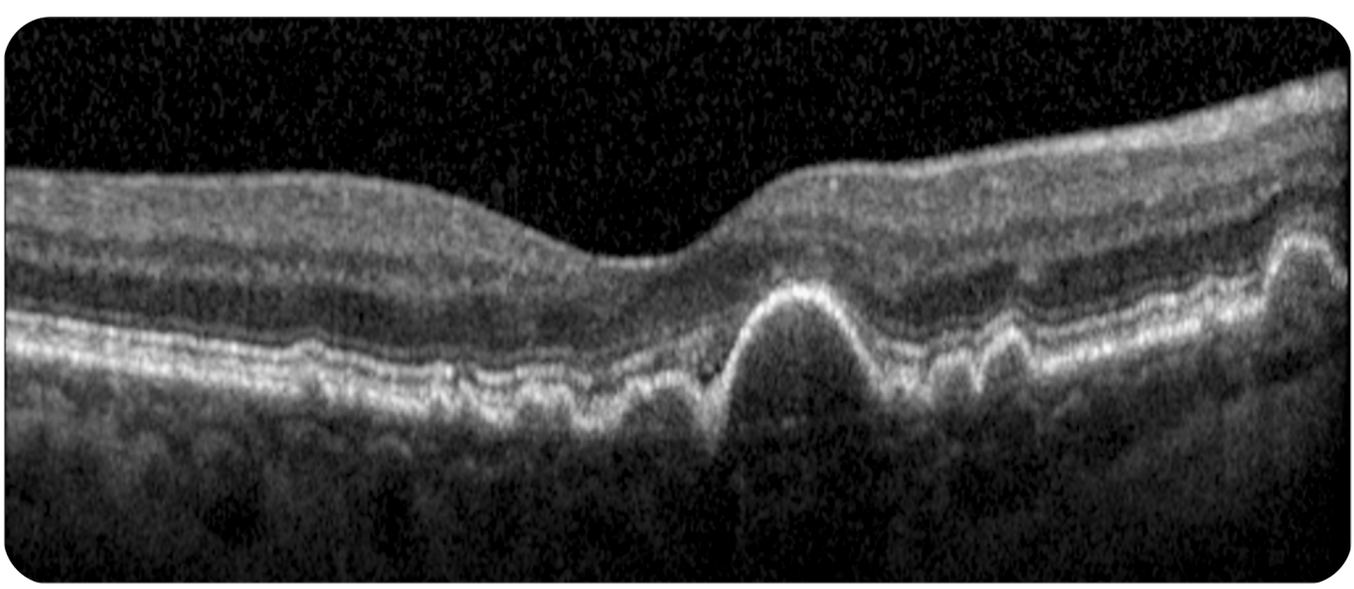
Age 74



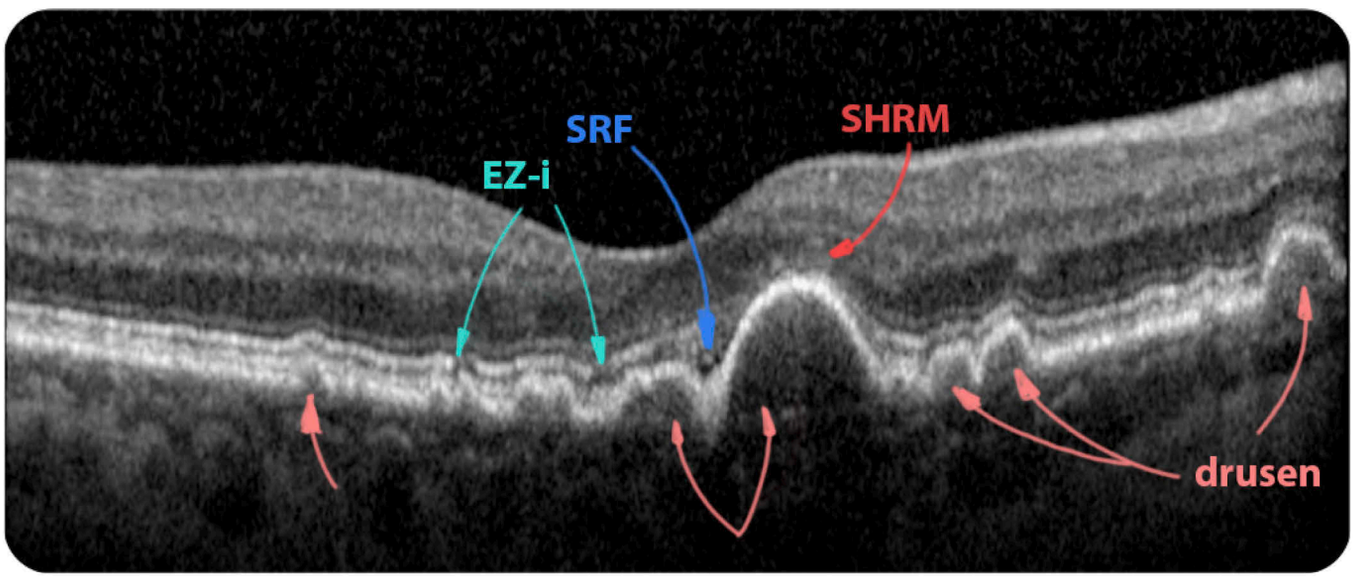
IR Image:
Multiple drusen in the macular area and a hyperreflective spot right at the fovea.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 58



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Drusen, (drusenoid PED)
Subretinal	PR	EZ interrupted
	SHRM	Suspect
	SRF	Suspect

Interpretation

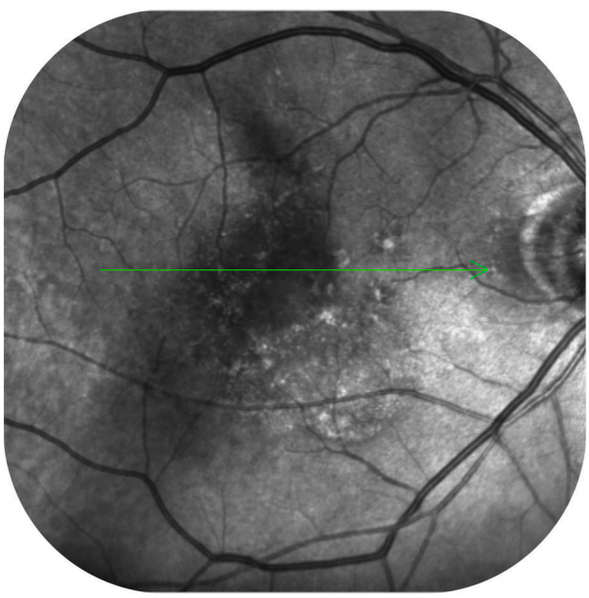
This patient has multiple drusen of varying sizes consistent with **AMD**. At the apex of the large hyporeflective PED, there is a SHRM-suspect area with an associated minimal SRF accumulation, which, could represent pseudo-SRF as the high PED may cause a detachment of the retina with minimal SRF accumulation. An OCT-A or FA would help to rule out an MNV. The EZ, is interrupted, negatively affecting the visual prognosis.

RPE: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **OCT-A:** Optical Coherence Tomography Angiography – **FA**: Fluorescein Angiography – **MNV**: Macular Neovascularization – **AMD:** Age-related Macular Degeneration

Case 59

Case 59

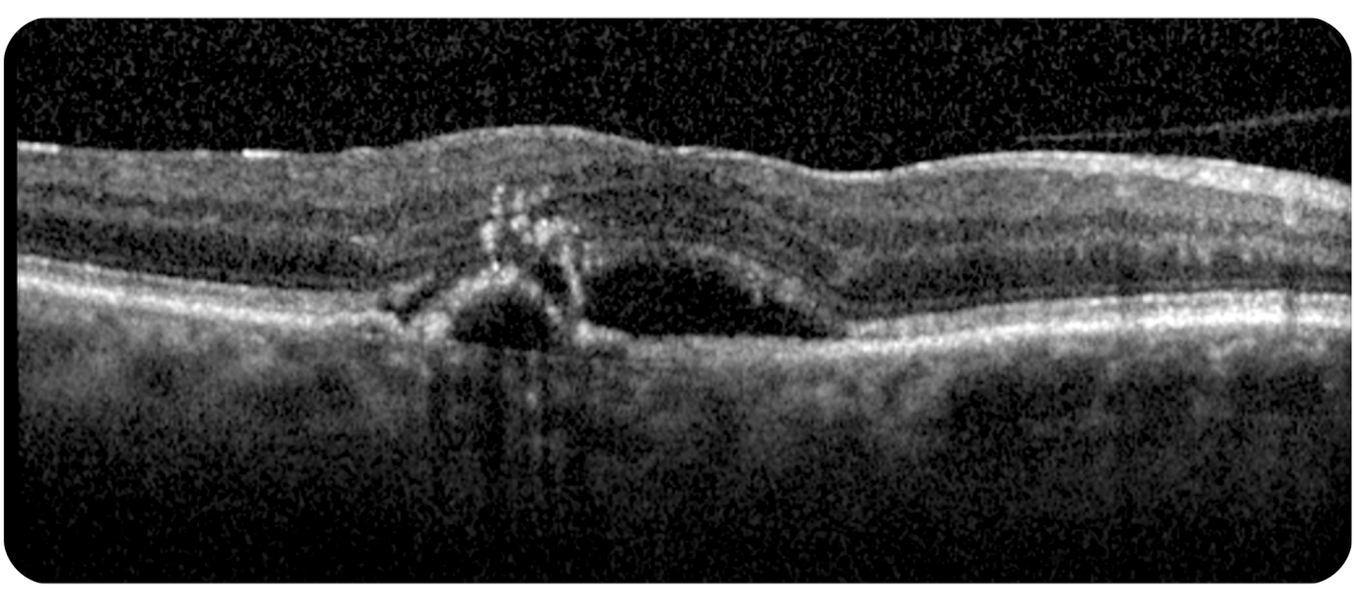
Age 74



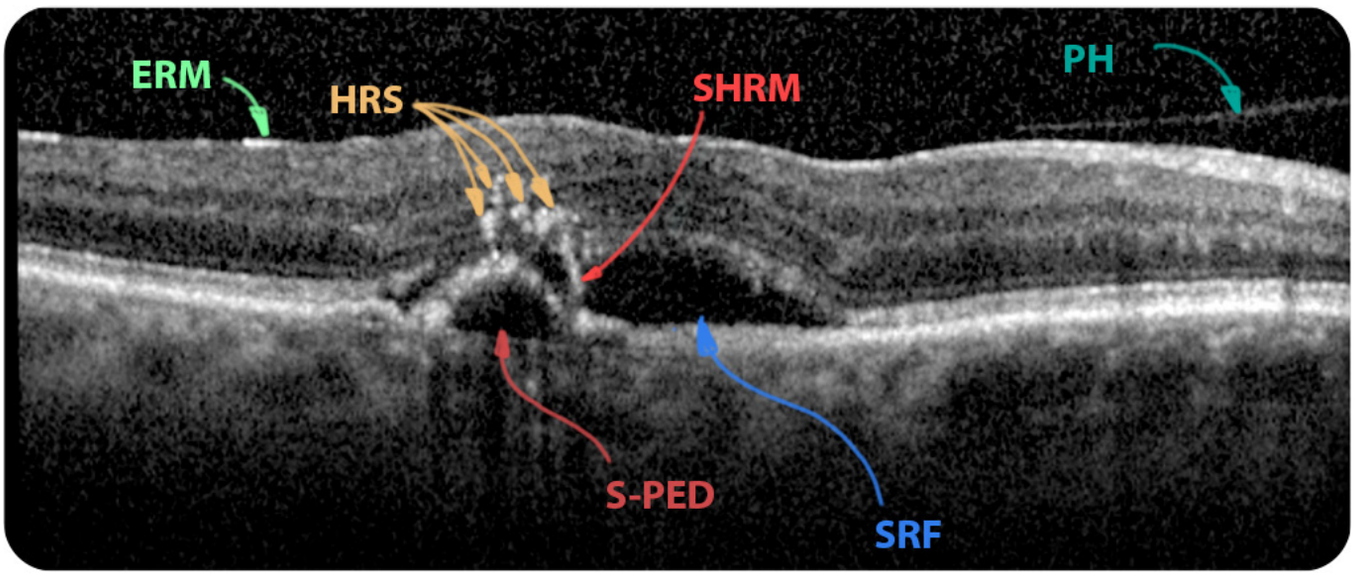
IR Image:
Large hyporeflective area and multiple bright speckled spots.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 59



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Hyporeflective S-PED
Subretinal	SRF	Exudation
	SHRM	Fuzzy
Intraretinal	HRS	Predominantly in the outer retina
Epiretinal	ERM	Thin ERM or Hyaloid
Preretinal	PH	Posterior hyaloid

Interpretation

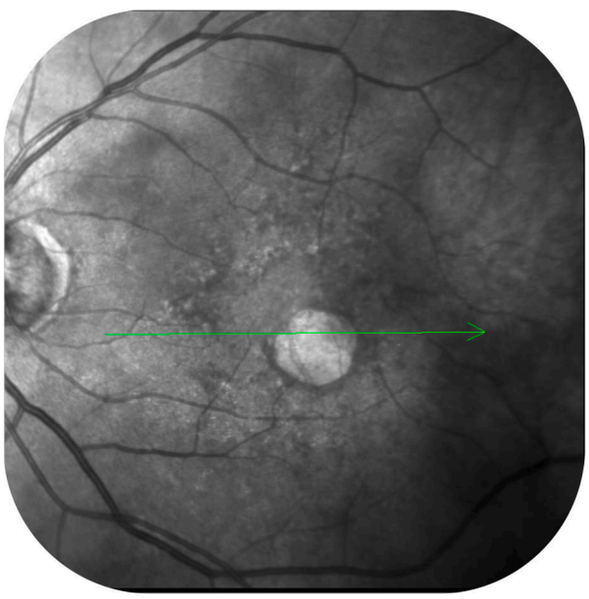
The most striking feature of this eye is the significant accumulation of SRF as well as a S-PED. The SHRM is suspect to an MNV but could also represent pigment migration. The PR layer over the SRF is ill-defined, which could indicate PR atrophy and the HRS likely represents migrated RPE. In the preretinal area a thin hyperreflective area on the left side could represent an ERM. It could also represent the hyaloid as it is not uncommon to have vitreoschisis; on the right side, the posterior hyaloid is visible. Enhanced depth imaging would allow us to better visualize choroidal thickness (CSC) and an OCT-A/FA could rule out an MNV.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **S-PED**: Serous PED – **SRF**: Subretinal Fluid – **SHRM**: Subretinal Hyperreflective Material – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **PH**: Posterior Hyaloid – **FA**: Fluorescein Angiography – **MNV**: Macular Neovascularization – **PR:** Photoreceptor – **CSC:** Central Serous Chorioretinopathy – **OCT-A:** Optical Coherence Tomography Angiography – **FA**: Fluorescein Angiography

Case 60

Case 60

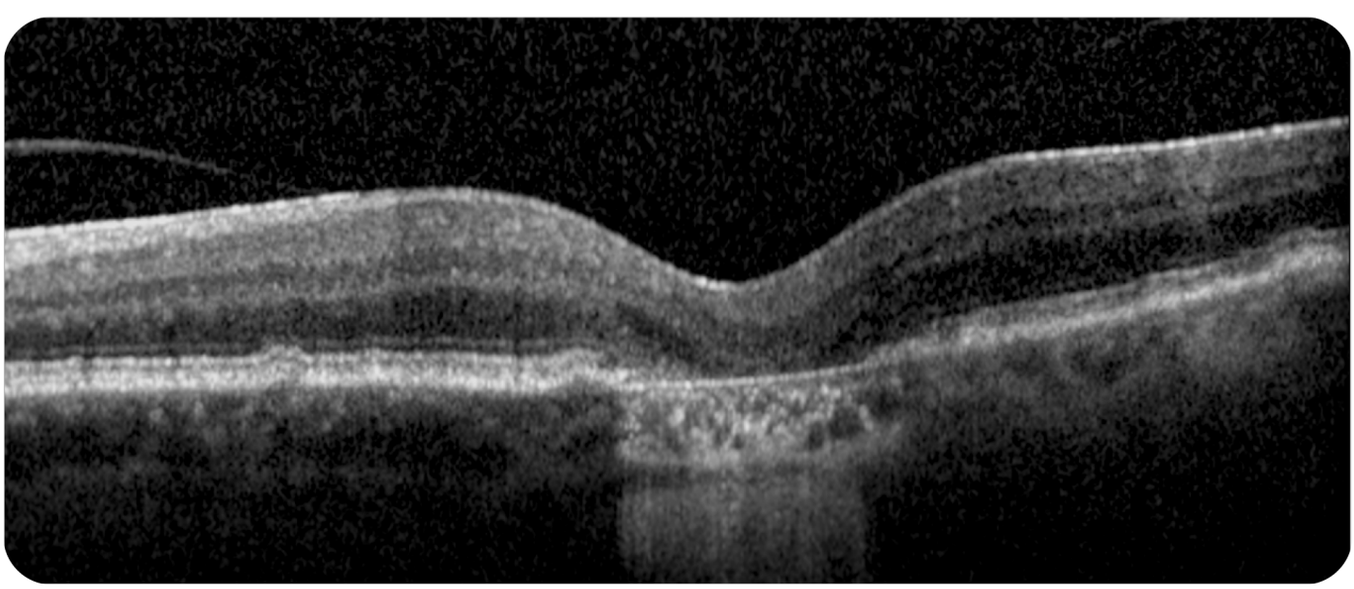
Age 89



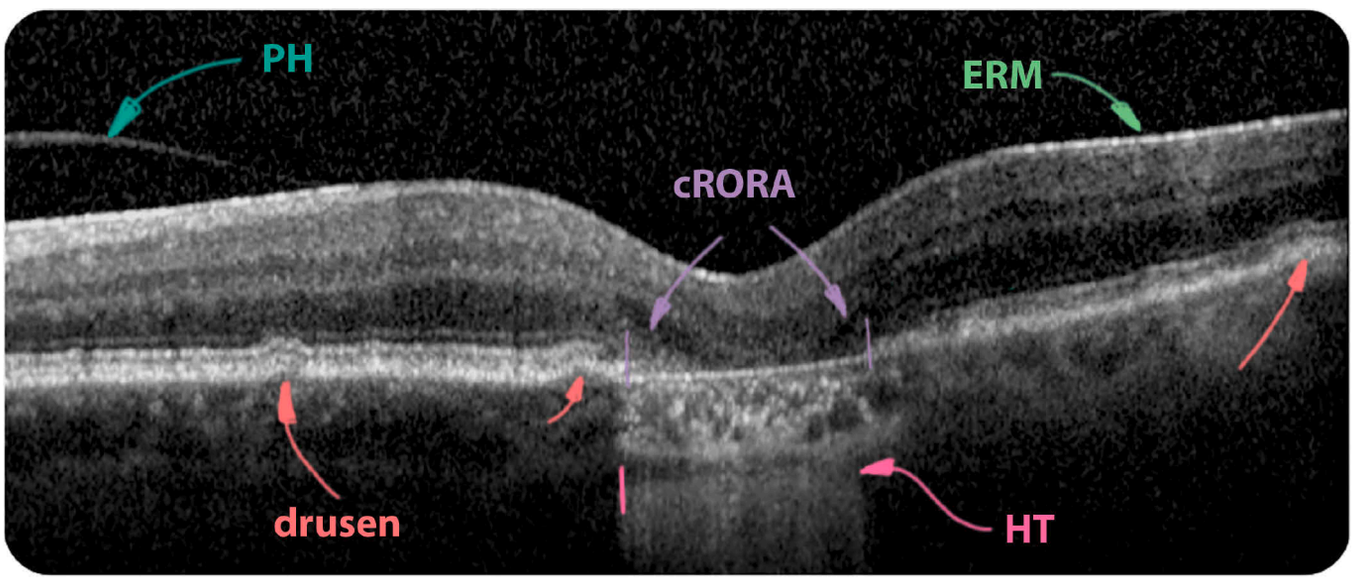
IR Image:
The macular region has an irregular appearance, and there is a large round area of RPE atrophy with visualized choroidal vessels.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 60



Findings

Area	Alteration	Description
Sub-RPE	RPE	Interrupted
	Atrophy	GA (cRORA)
	PED	Drusen
Subretinal	PR	PR atrophy
Epiretinal	ERM	Thin
Preretinal	PH	Posterior hyaloid

Interpretation

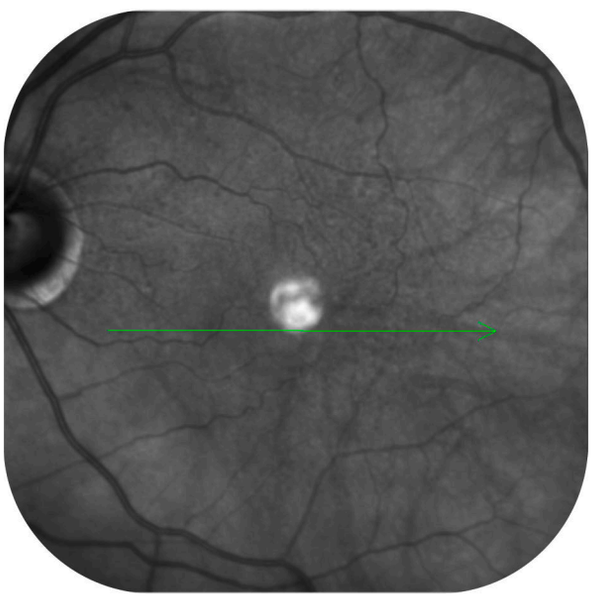
This scan's most striking feature is the area of complete RPE and PR atrophy, which is consistent with **GA in AMD** (cRORA). Additionally, there are multiple small drusen. In the preretinal area, one can see a thin ERM and the posterior hyaloid.

RPE: Retinal Pigment Epithelium – **GA**: Geographic Atrophy – **cRORA**: Complete RPE and Outer Retinal Atrophy – **PED**: Pigment Epithelial Detachment – **PR**: Photoreceptor – **ERM**: Epiretinal Membrane – **PH**: Posterior Hyaloid – **ERM**: Epiretinal Membrane – **HT:** Hypertransmission – **AMD:** Age-related Macular Degeneration

Case 61

Case 61

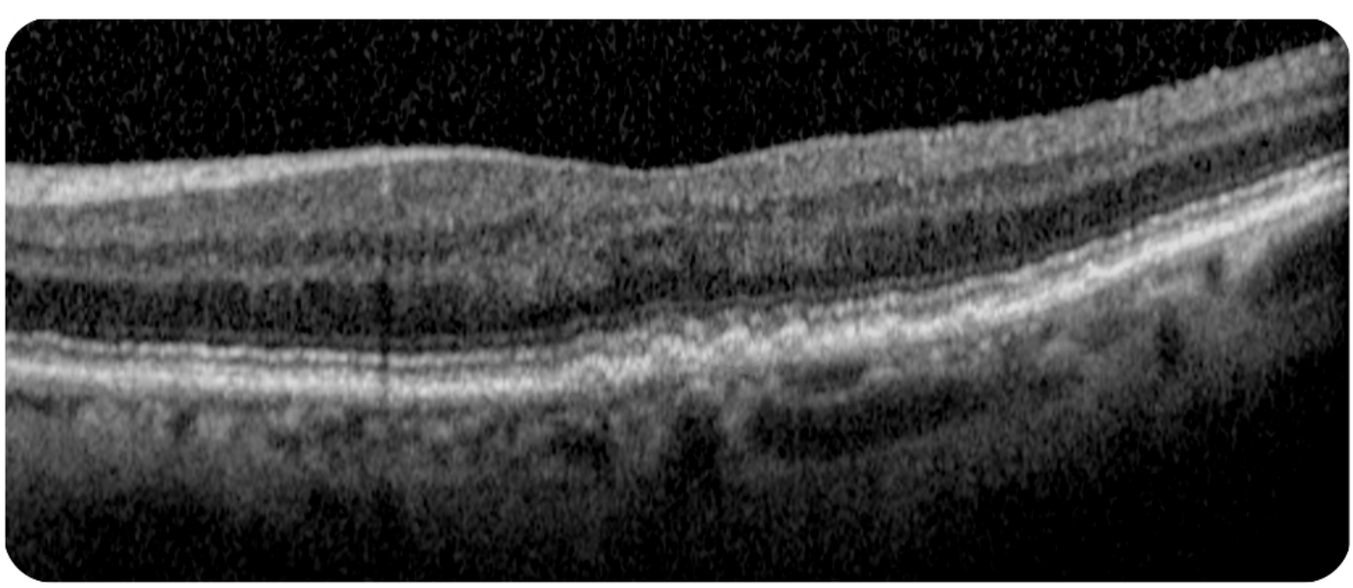
Age 68



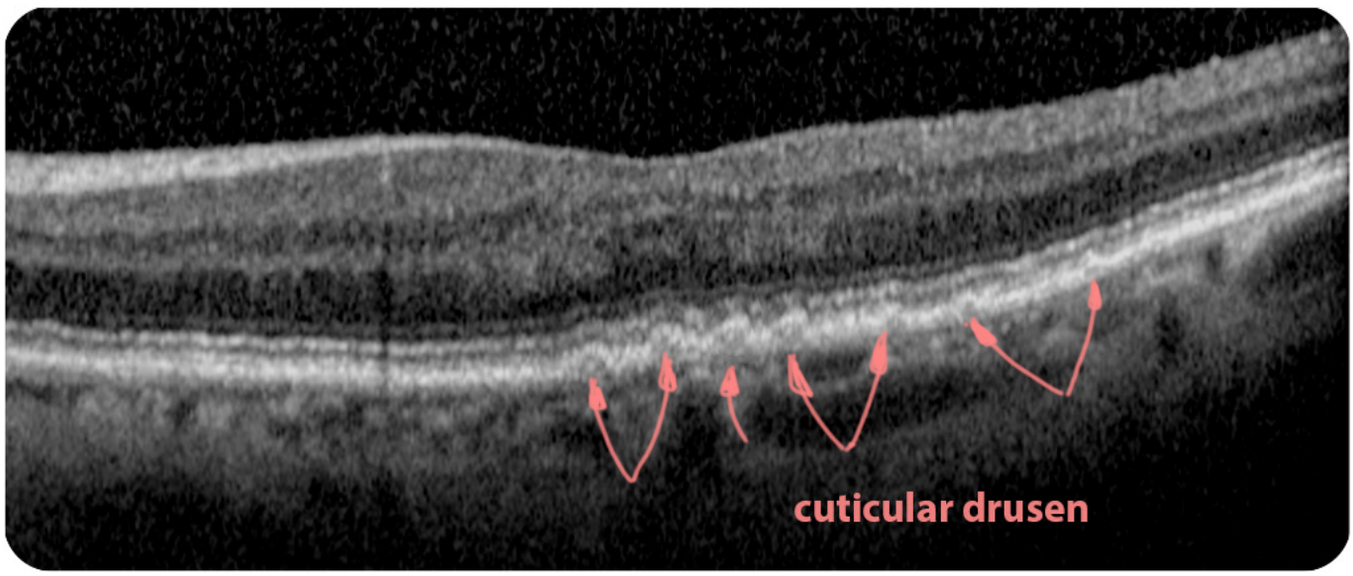
IR Image:
A bright light-reflex-artifact can be seen at the fovea as well as some irregularity, especially in the superior perifoveal area.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 61



Findings

Area	Alteration	Description
Sub-RPE	RPE	Irregular, elevated
	Drusen	Multiple

Interpretation

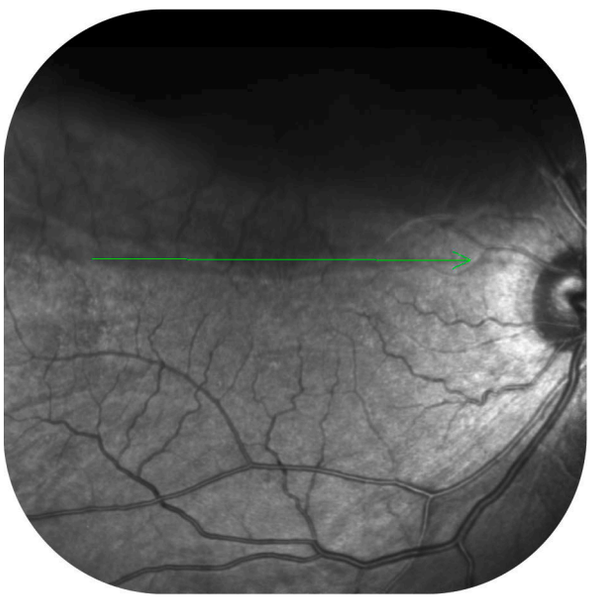
We are looking at a patient with cuticular drusen with its classic sawtooth appearance. This patient has **AMD**.

RPE: Retinal Pigment Epithelium – **AMD:** Age-related Macular Degeneration

Case 62

Case 62

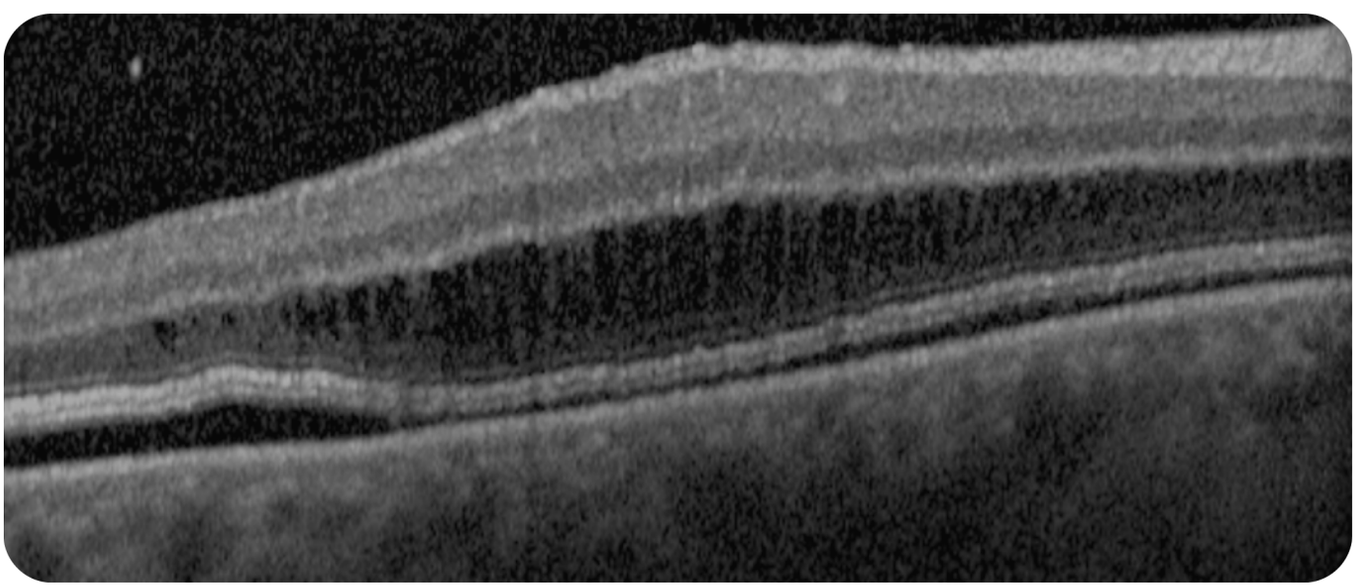
Age 62



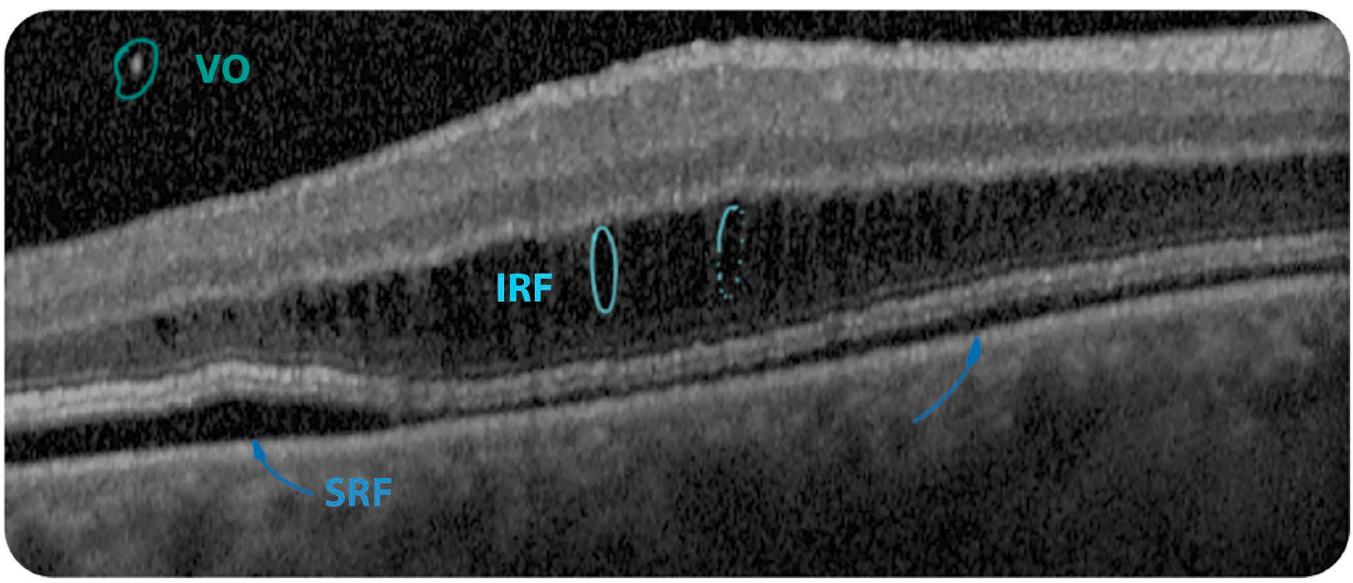
IR Image:
The superior hemisphere appears hyporeflective with a well-demarcated margin.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 62



Findings

Area	Alteration	Description
Subretinal	SRF	Widespread SRF accumulation
Intraretinal	IRF	Widespread
Preretinal	VO	HRS in the vitreous

Interpretation

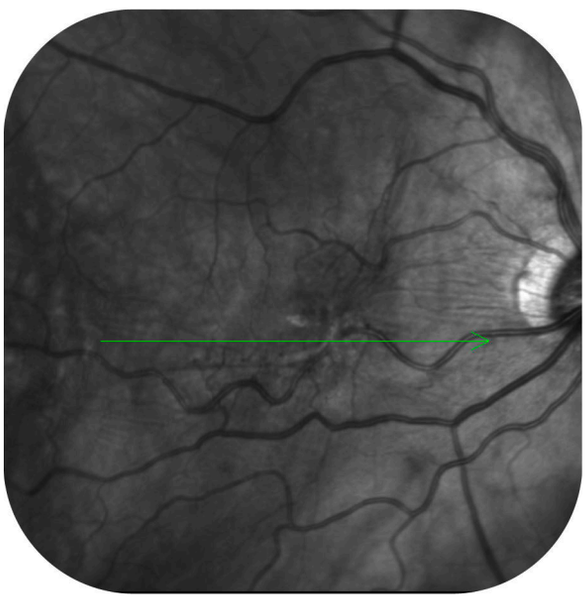
This patient has a widespread accumulation of SRF, causing a detachment of the retina. It is accompanied by a diffuse retinal edema. There is a HRS in the vitreous, which could represent blood or an opacity. In conjunction with the findings in the IR image, this patient is likely suffering from a **retinal detachment**.

SRF: Subretinal Fluid – **IRF**: Intraretinal Fluid – **VO**: Vitreous Opacity – **HRS**: Hyperreflective Spot

Case 63

Case 63

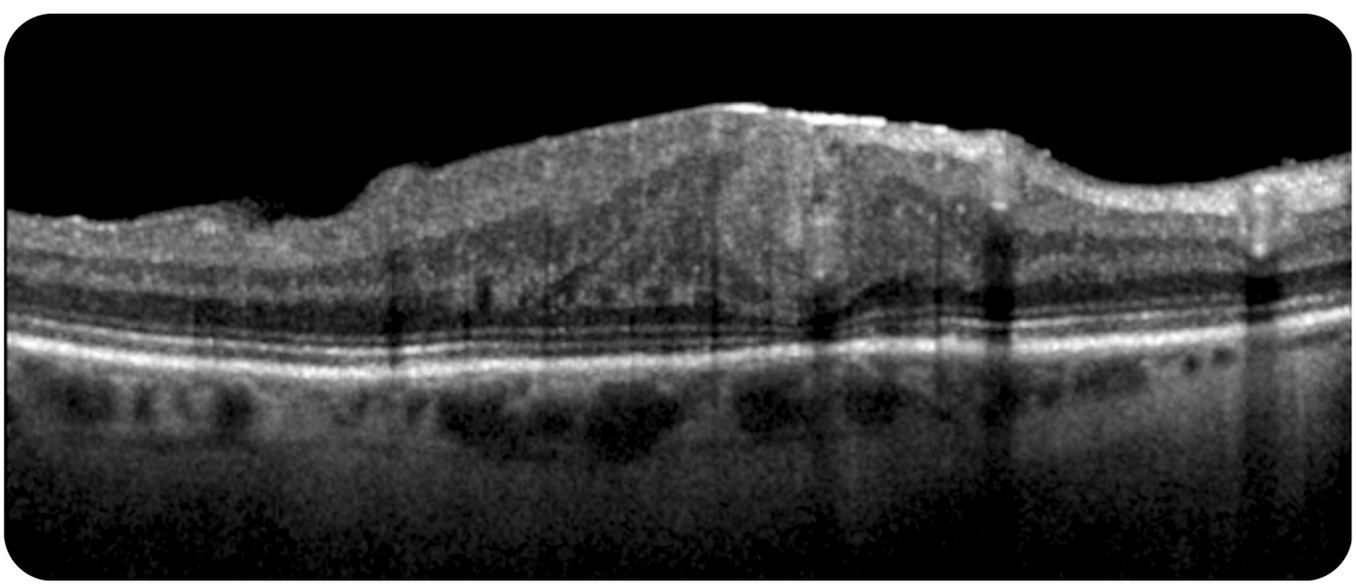
Age 70



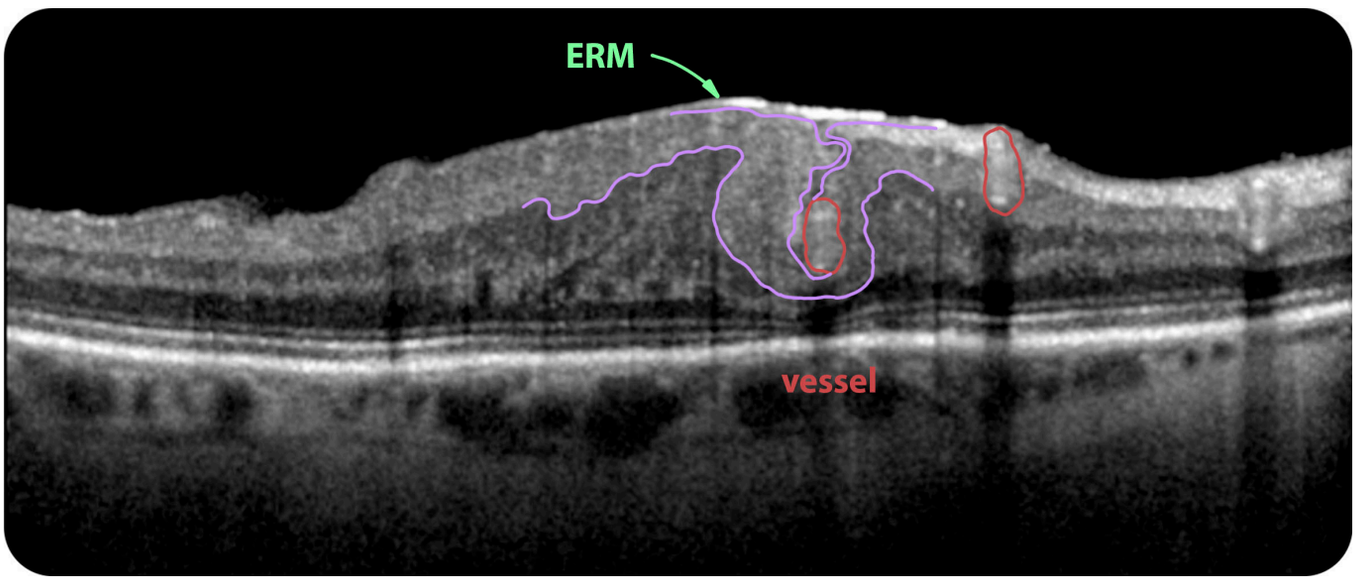
IR Image:
Ventral hyporeflective area and a wrinkled appearance temporal to the disc.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 63



Findings

Area	Structure	Description
Intraretinal	IRL	Disorganization
Epiretinal	ERM	Epiretinal membrane

Interpretation

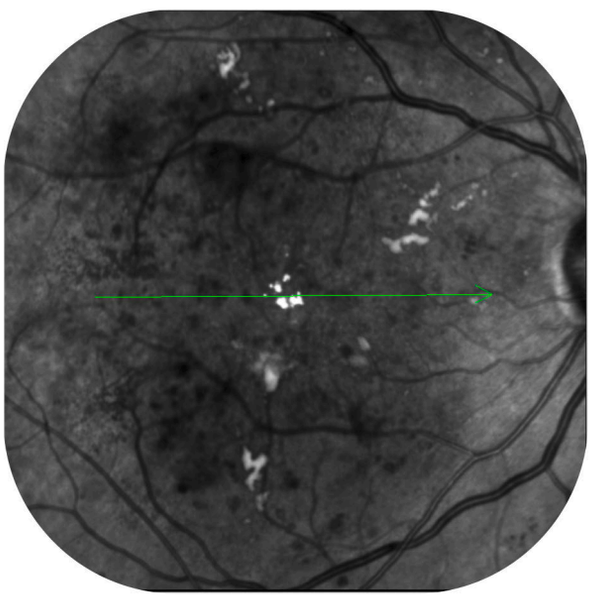
The most striking feature of this scan is the severe **disorganization of the retinal layers**. The **ERM** seems to cause folding (invagination) of the retina, displacing a retinal vessel.

IRL: Inner Retinal Layers – **ERM:** Epiretinal Membrane

Case 64

Case 64

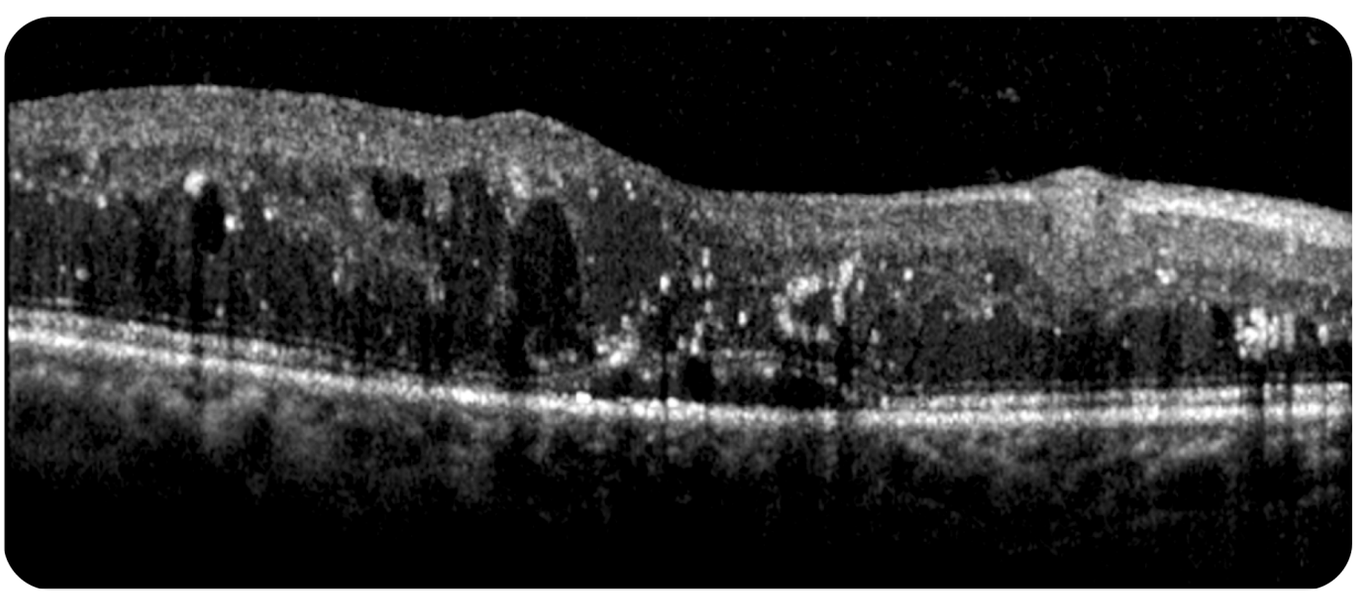
Age 67



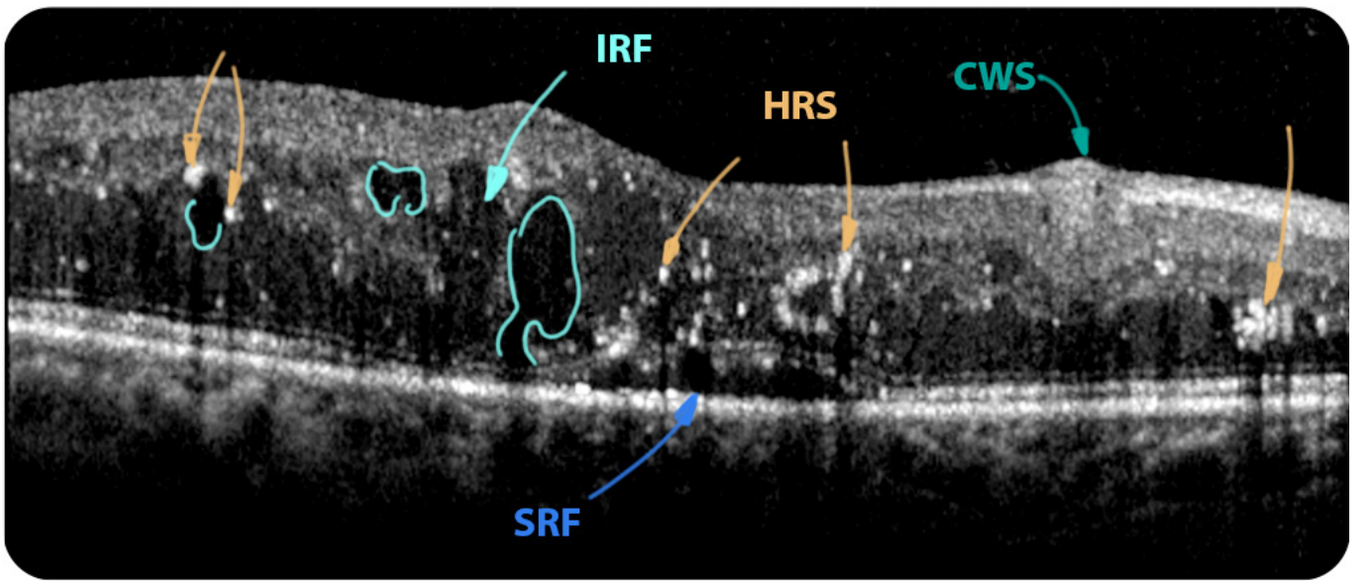
IR Image:
The entire macula has a dark appearance. Notice the flame-shaped and blot-shaped hemorrhages as well as microaneurysms. The bright spots likely represent hard exudates.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 64



Findings

Area	Alteration	Description
Subretinal	SRF	Associated to CME
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudates
	CWS	Cotton wool spot

Interpretation

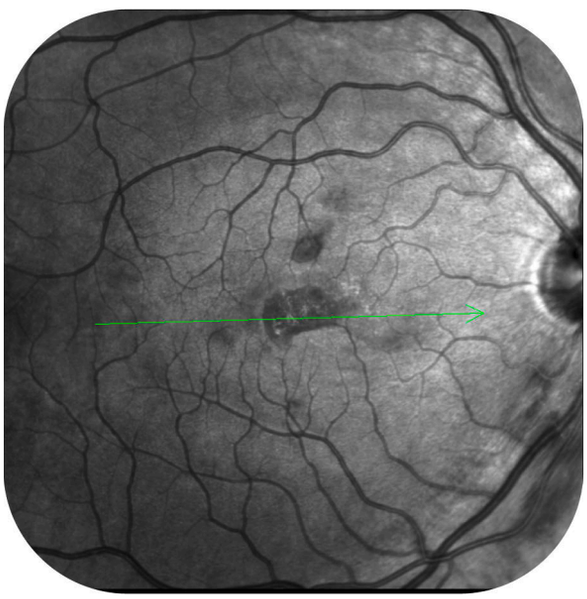
We are looking at an eye with a widespread and diffuse accumulation of IRF and an area with SRF. There are disseminated HRS that represent hard exudates and a localized swelling of the inner retinal layers (cotton wool spot). These findings in conjunction with the IR image are consistent with DR, so this patient likely has a **diabetic macular edema.**

SRF: Subretinal Fluid – **CME**: Cystoid Macular Edema – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **CWS**: Cotton Wool Spots – **DR**: Diabetic Retinopathy

Case 65

Case 65

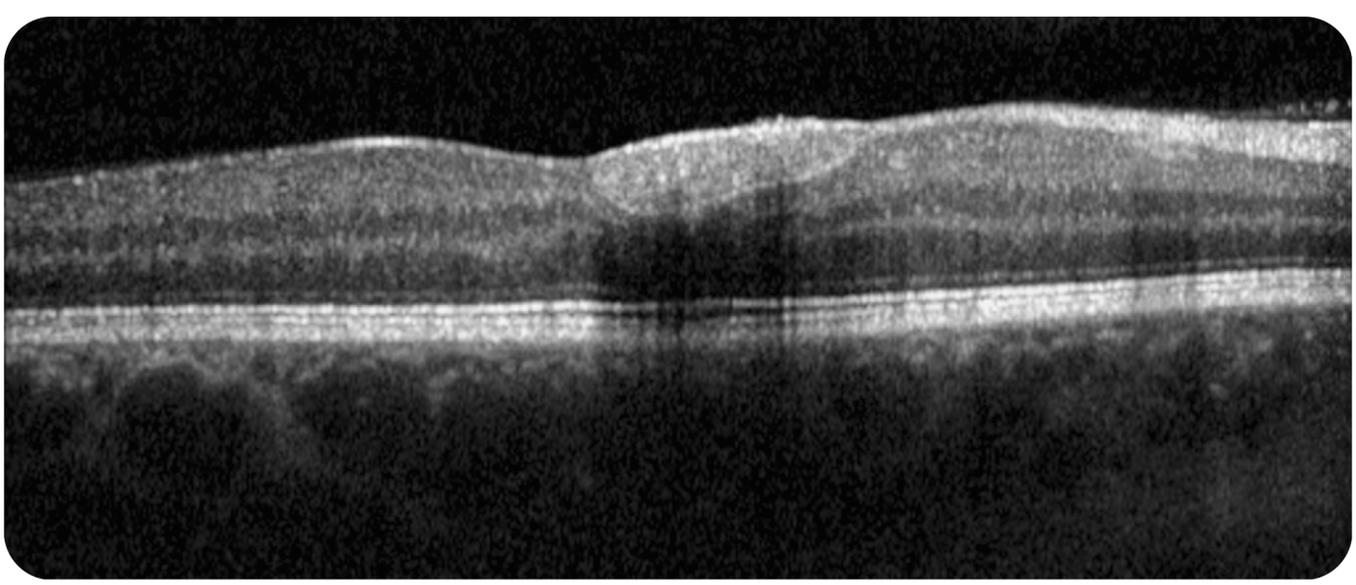
Age 68



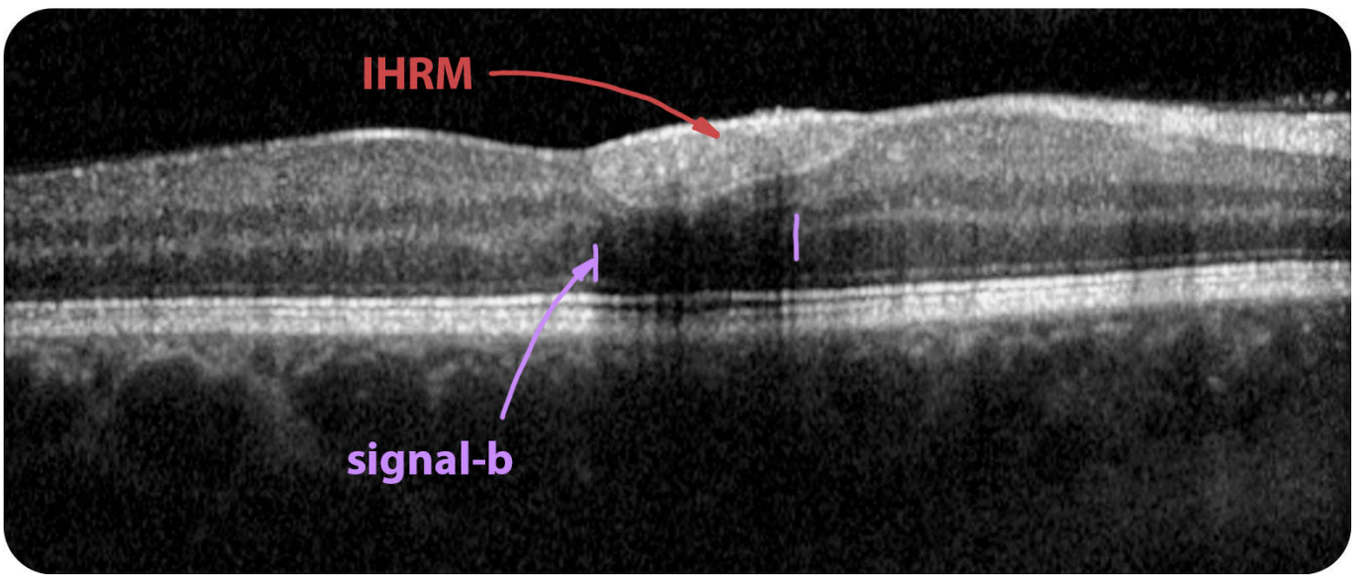
IR Image:
A well-demarcated hyporeflective area right at the fovea and a smaller one in the superior perifoveal section.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 65



Findings

Area	Alteration	Description
Intraretinal	IHRM	Local thickening with signal blockage

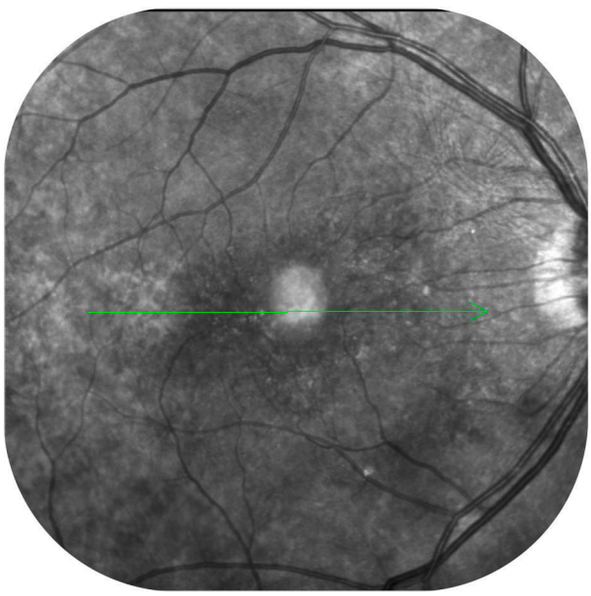
Interpretation

This patient suffers from a **sub-ILM hemorrhage** that presents as hyperreflective material, causing posterior signal blockage (signal-b). Otherwise, this scan looks inconspicuous.

IHRM: Intraretinal Hyperreflective Material – **ILM**: Inner Limiting Membrane – **Signal-b**: Signal blockage

Case 66

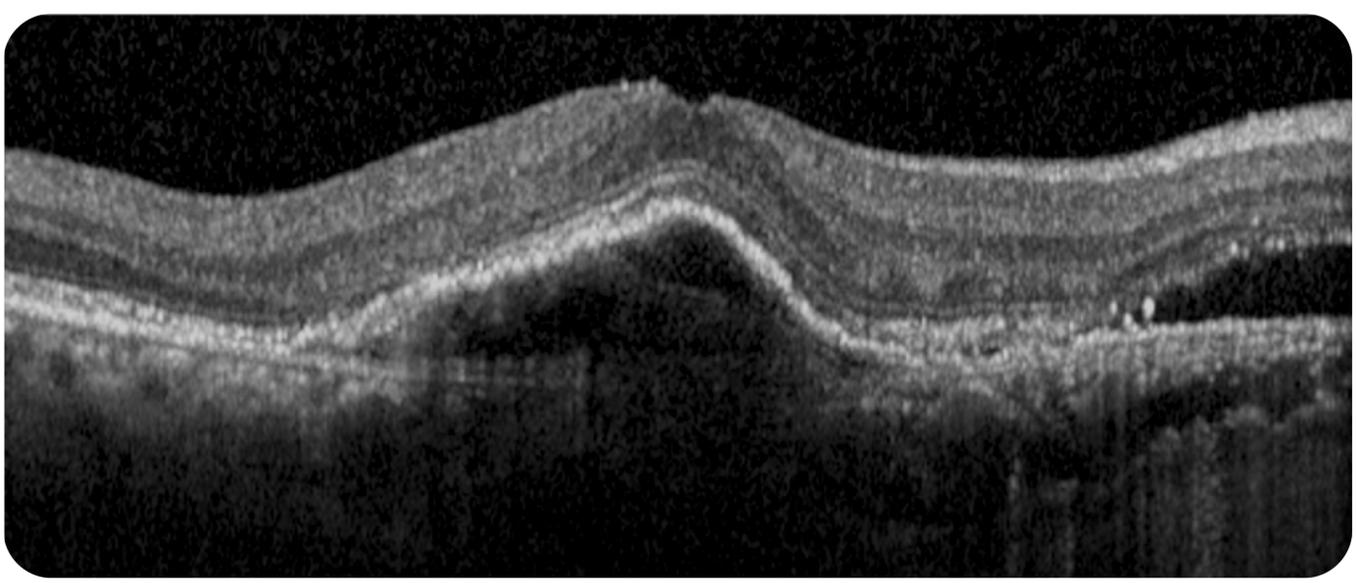
Age 72



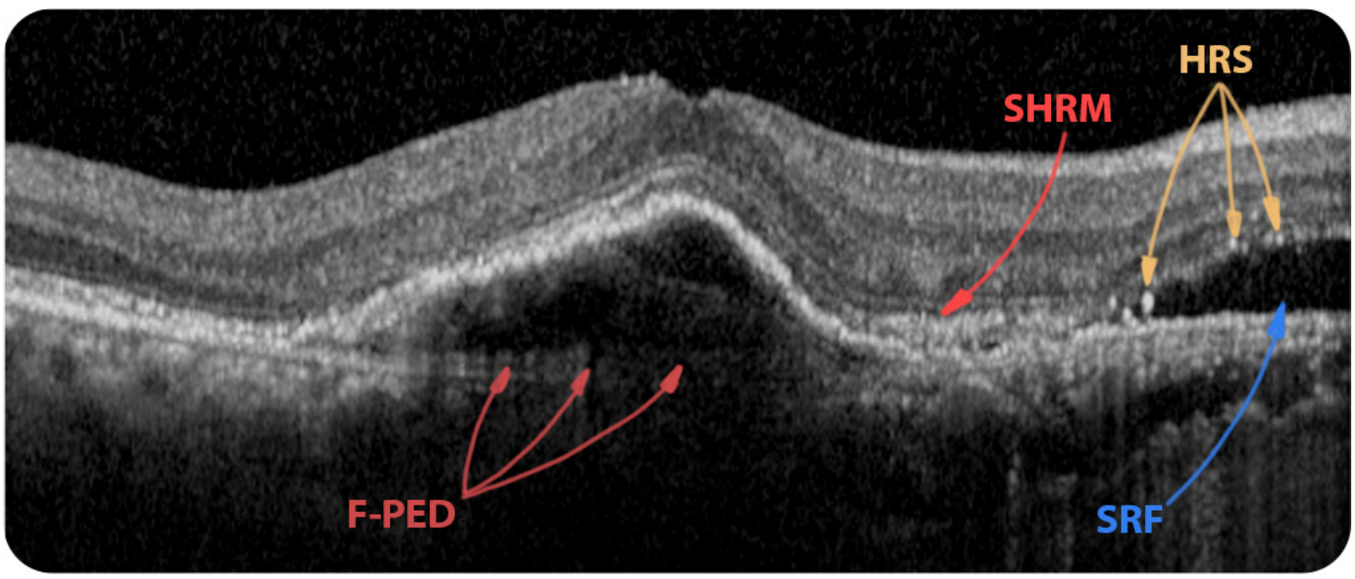
IR Image:
Hyporeflective appearance of the foveal and perifoveal area – consistent with fluid accumulation. Notice the light-reflex artifact right in the center. There is some wrinkling of the retinal surface along the superior vascular arcade.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 66



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Fibrovascular PED
Subretinal	SHRM	Medium reflective
	SRF	Exudation
	PR	Granulated and atrophic appearance
Intraretinal	HRS	Associated to PR thinning

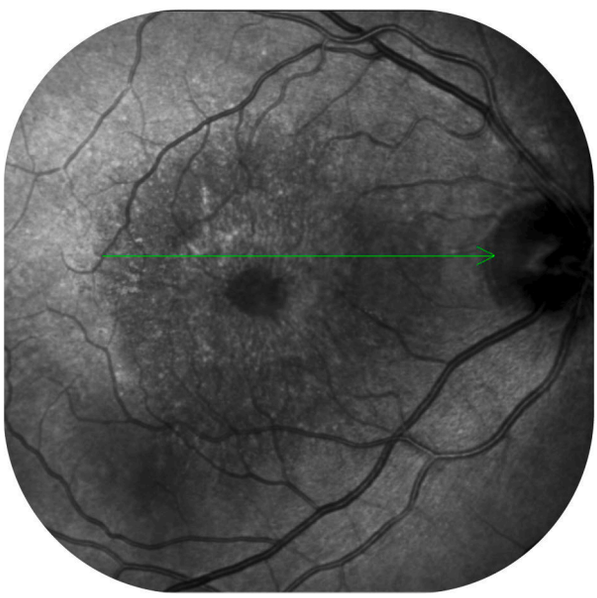
Interpretation

There is a large heterogenous, hyporeflective PED right in the center of the scan, likely representing a fibrovascular PED. The shadowy contours inside the F-PED could represent a neovascular membrane. On the right side of the F-PED, one can find SHRM-suspect material and an accumulation of SRF. We are looking at an **active MNV**, which is a type 1 variant – it could, however, also have a type 2 component. In conjunction with the PR thinning, the HRS likely represent degenerated retinal tissue or macrophages engulfing it.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization

Case 67

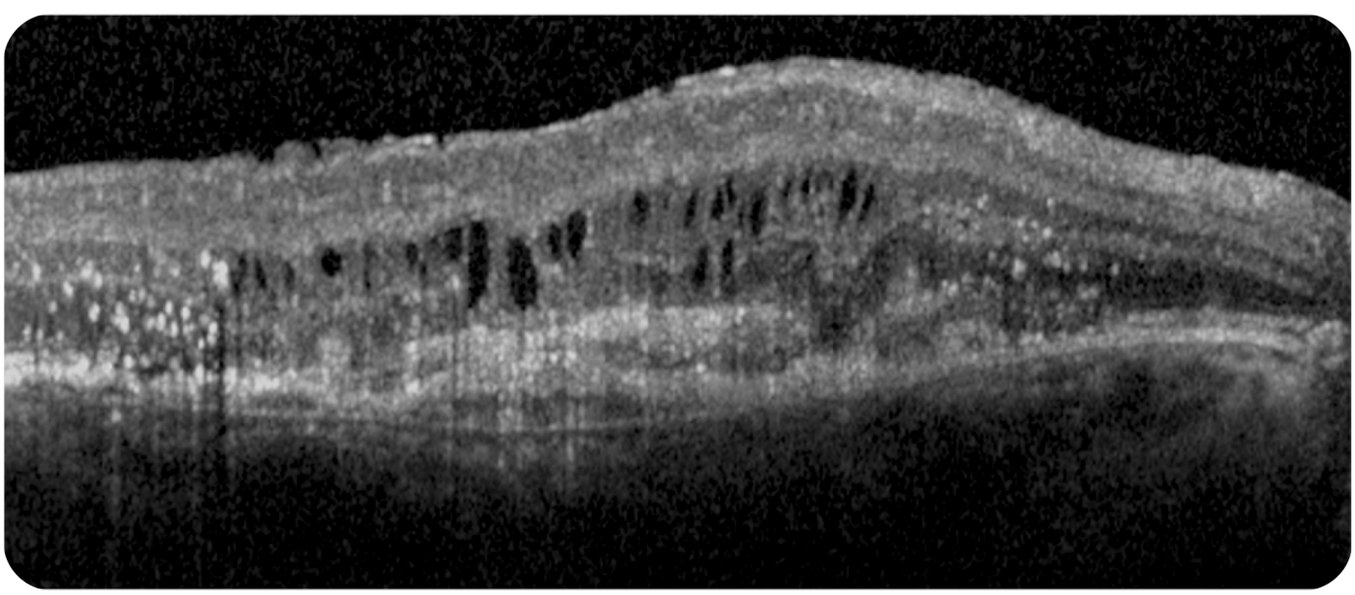
Age 84



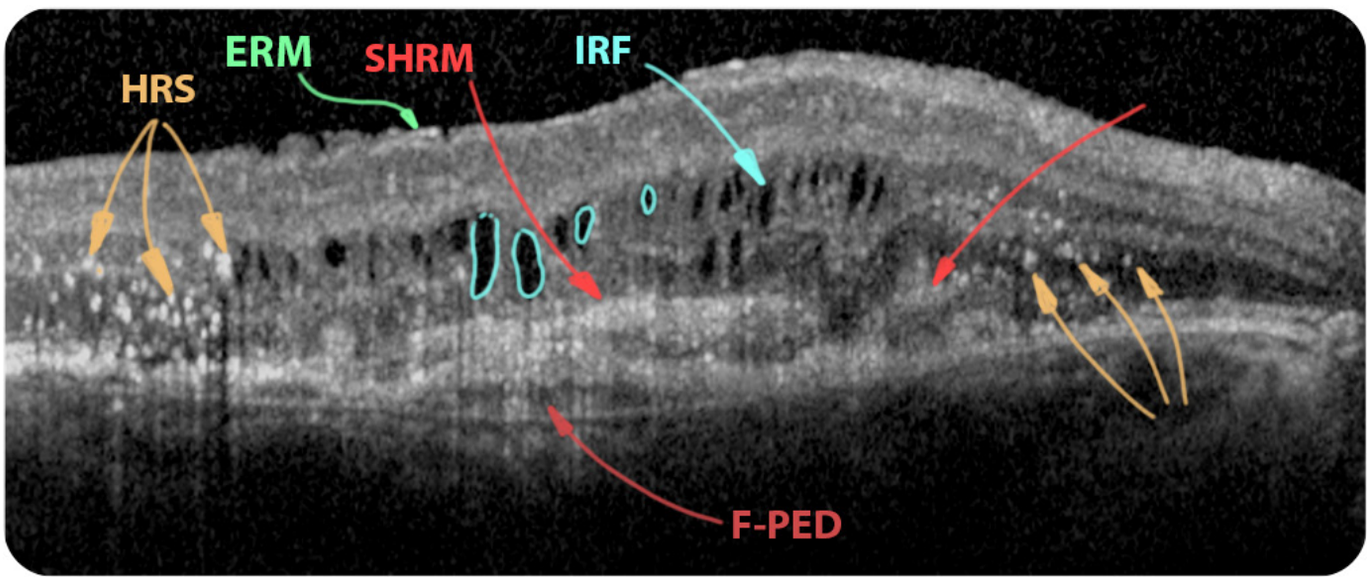
IR Image:
The fovea has a very dark appearance and is surrounded by a hyporeflective perifovea.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 67



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Fibrovascular PED
Subretinal	SHRM	Solid and fuzzy
Intraretinal	IRF	Widespread
	HRS	Exudate
	ERM	Thin

Interpretation

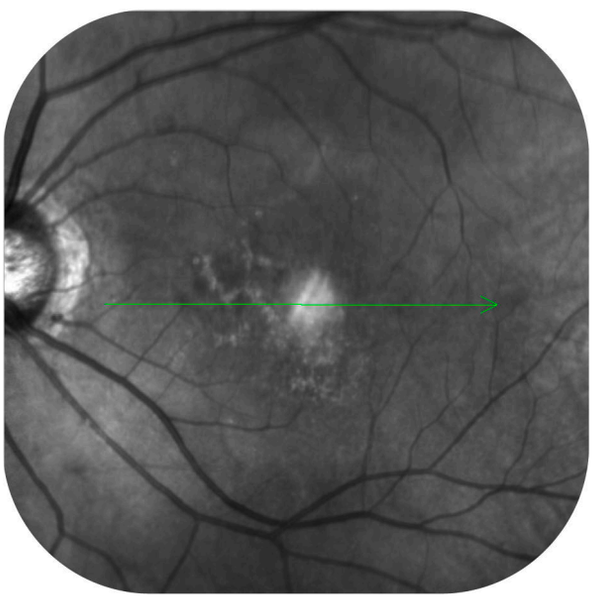
There is a widespread fibrovascular PED and large amounts of SHRM above it. The SHRM has a solid (left) and fuzzy (right) appearance consistent with fibrotic tissue and a type 2 MNV. The widespread IRF accumulation is a sign of an active exudation, and the HRS probably represent lipid exudates as a sign of blood-retinal barrier breakdown. Thus, this patient is very likely suffering from a prolonged disease course with an active, **mixed type MNV and consolidated fibrotic tissue**.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization – **SHRM**: Subretinal Hyperreflective Material

Case 68

Case 68

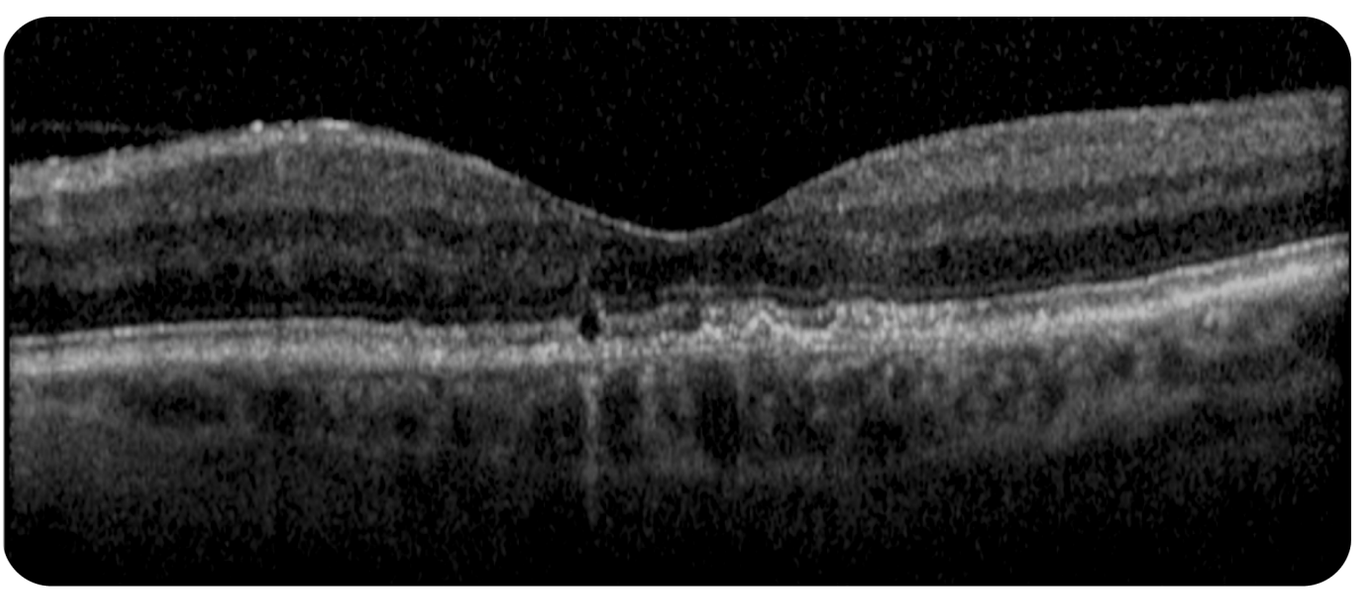
Age 74



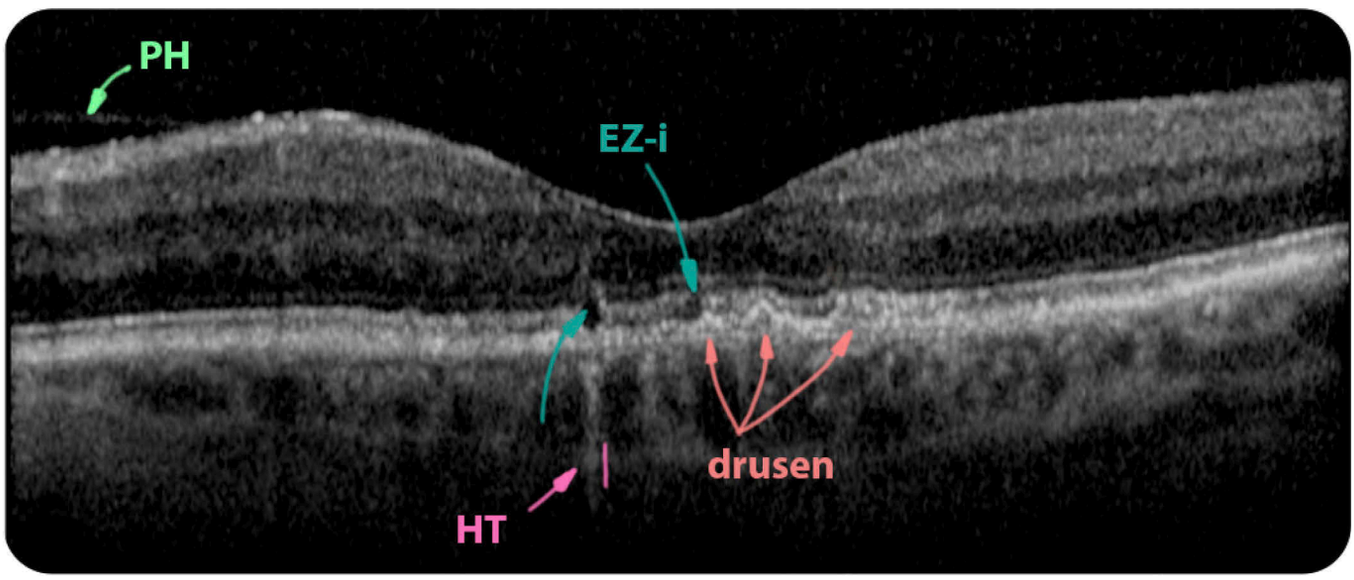
IR Image:
Speckled hyperreflective spots are noted around the macular region with a hyporeflective area left to the fovea and a light-reflex artifact in the center.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 68



Findings

Area	Alteration	Description
Subretinal	RPE	Elevated
	PED	Drusen
	PR	EZ interrupted, PR atrophy
Preretinal	PH	Posterior hyaloid

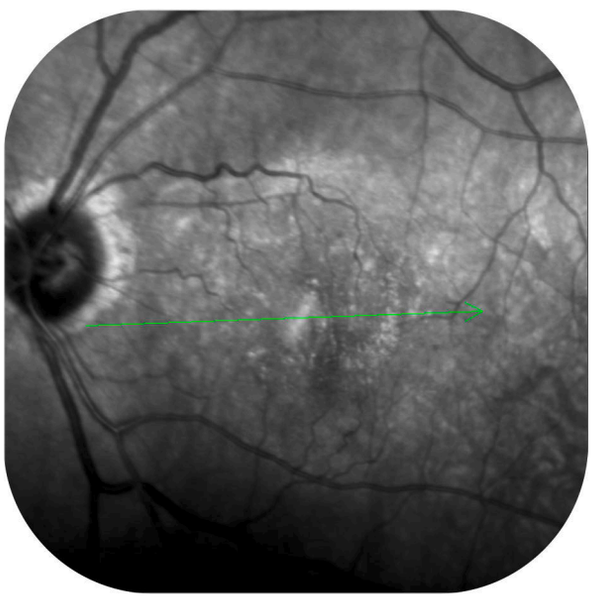
Interpretation

This patient has multiple small drusen grouped right at the fovea – a hallmark of **AMD**. Considering the irregular appearance and the DLS, a SIRE would be the next best thing to think of, leaving this patient with an increased risk for MNV development. There is a small local atrophy of the RPE and the PRs with adjacent signal hypertransmission resulting in a local hyporeflective defect. The EZ is interrupted right at the fovea, leaving this patient with a comparatively worse visual prognosis.

RPE: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **PR**: Photoreceptor – **PH**: Posterior Hyaloid – **HT:** Hypertransmission – **AMD:** Age-related Macular Degeneration

Case 69

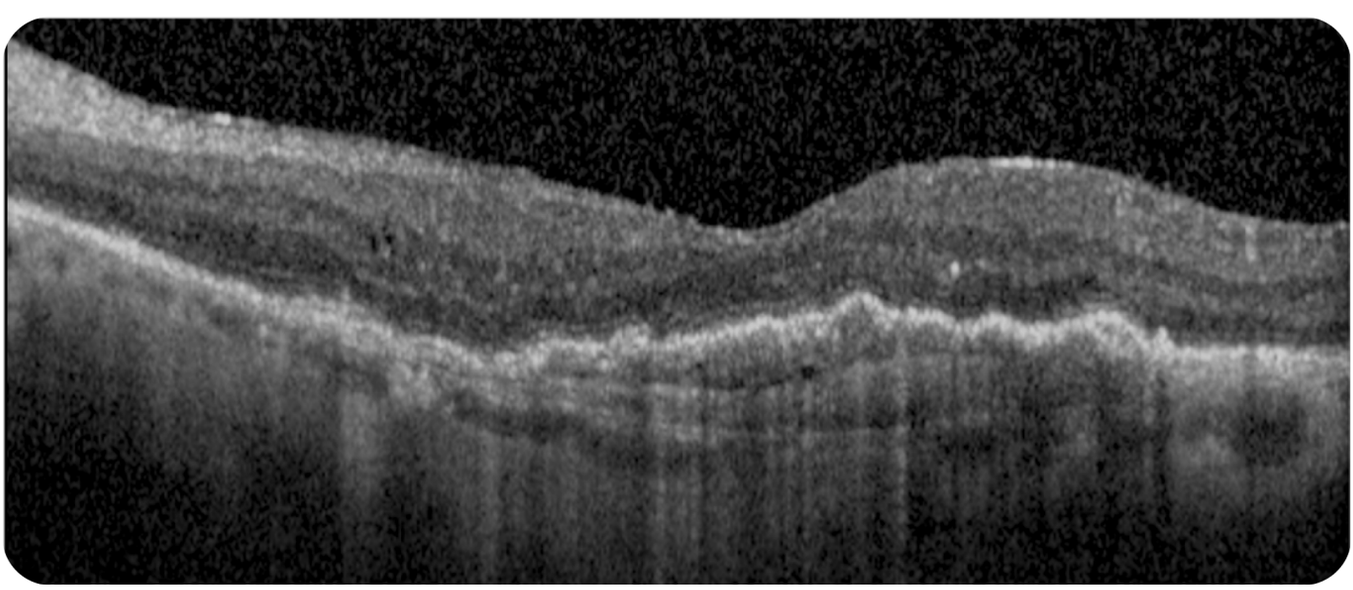
Age 70



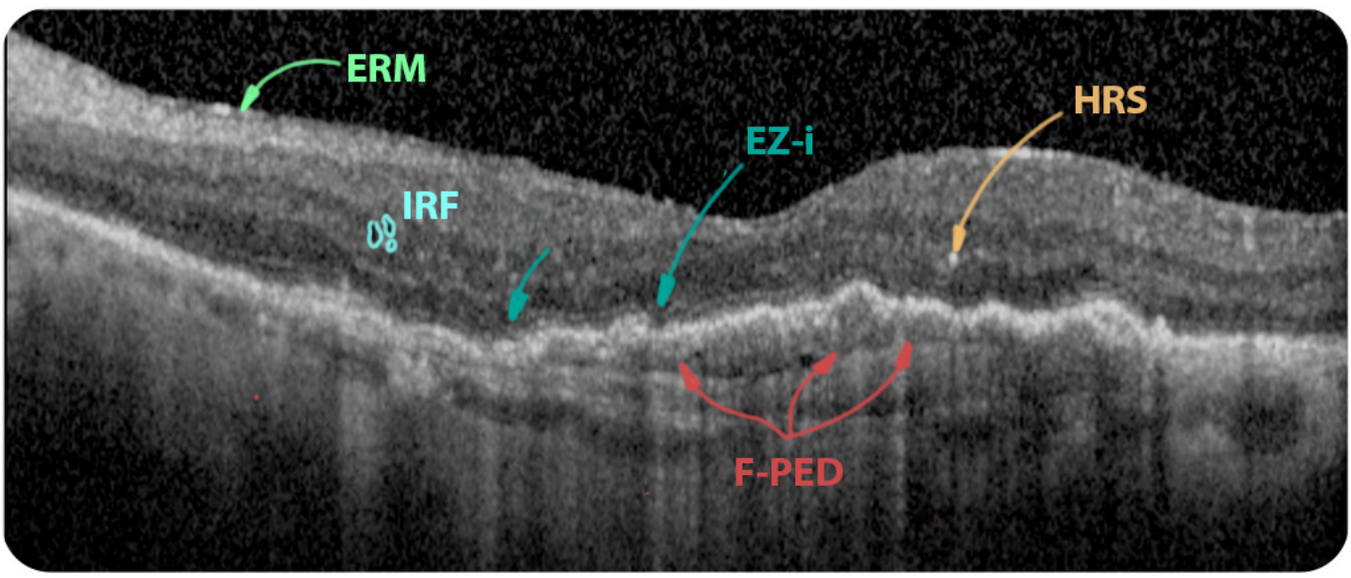
IR Image:
Irregular appearance of the parafoveal region with hypo- and hyperreflective areas.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 69



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Fibrovascular PED
Intraretinal	HRS	Around OPL
Epiretinal	ERM	Rare

Interpretation

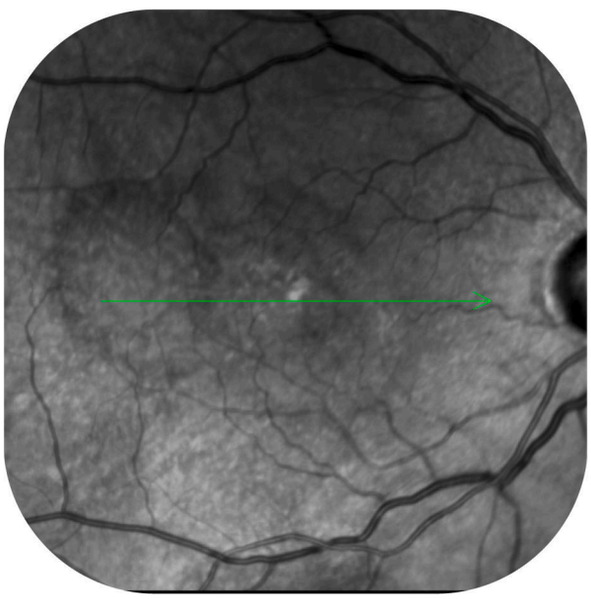
There is a large multilayered fibrovascular PED without SRF accumulation. This patient has likely already received multiple anti-VEGF injections (multilayered appearance of the F-PED). Therefore, this eye is highly suspicious of a **quiescent type 1 MNV**.

IRF: Intraretinal Fluid – **EZ-i:** Ellipsoid Zone Interruption – **RPE**: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **HRS**: Hyperreflective Spots – **ERM:** Epiretinal Membrane – **OPL**: Outer Plexiform Layer – **MNV**: Macular Neovascularization – **SRF:** Subretinal Fluid

Case 70

Case 70

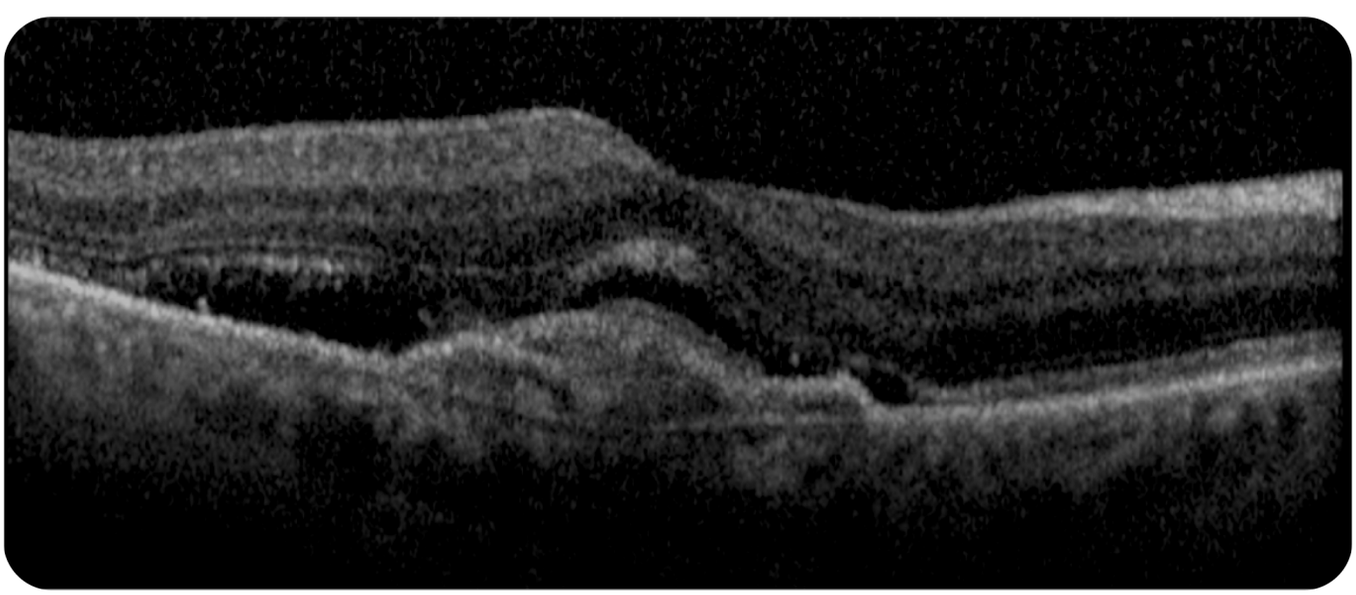
Age 73



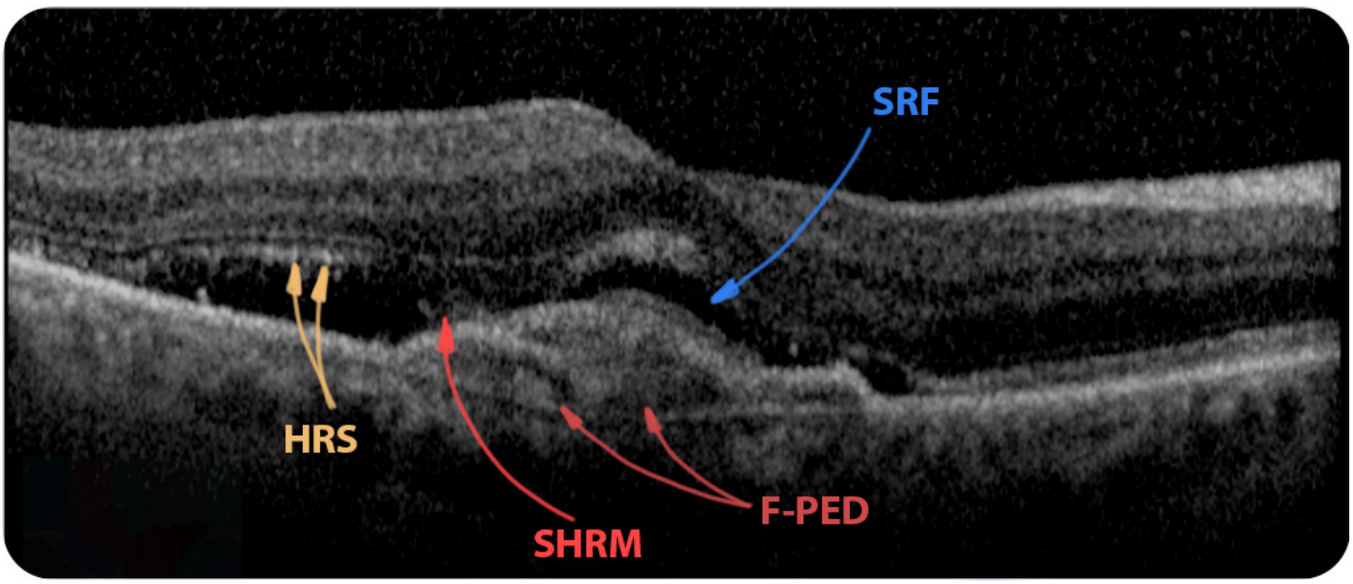
IR Image:
Large, hyporeflective demarcated circle around the temporal macula, and an irregular appearance of the fovea.

Scan Quality:
Reduced quality without artifacts

Location:
Fovea



Case 70



Findings

Area	Alteration	Description
Subretinal	RPE	Elevated
	PED	F-PED
	SHRM	Suspect
	SRF	Associated to F-PED
	PR	Atrophic appearance of PRs
Intraretinal	HRS	Associated to PR atrophy

Interpretation

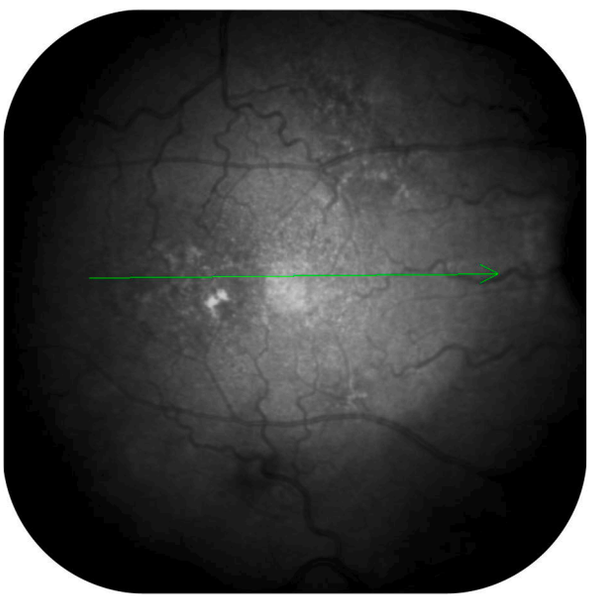
There is a large fibrovascular PED with associated SRF. On the left side of the PED, some ill-defined SHRM could represent a neovascular membrane that broke through the RPE. Along the SRF, the PR-layer appears atrophic with associated HRS, which could indicate a prolonged course of disease. This patient is very likely suffering from an **active type 1 MNV.**

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **F-PED**: Fibrovascular PED – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularizationn

Case 71

Case 71

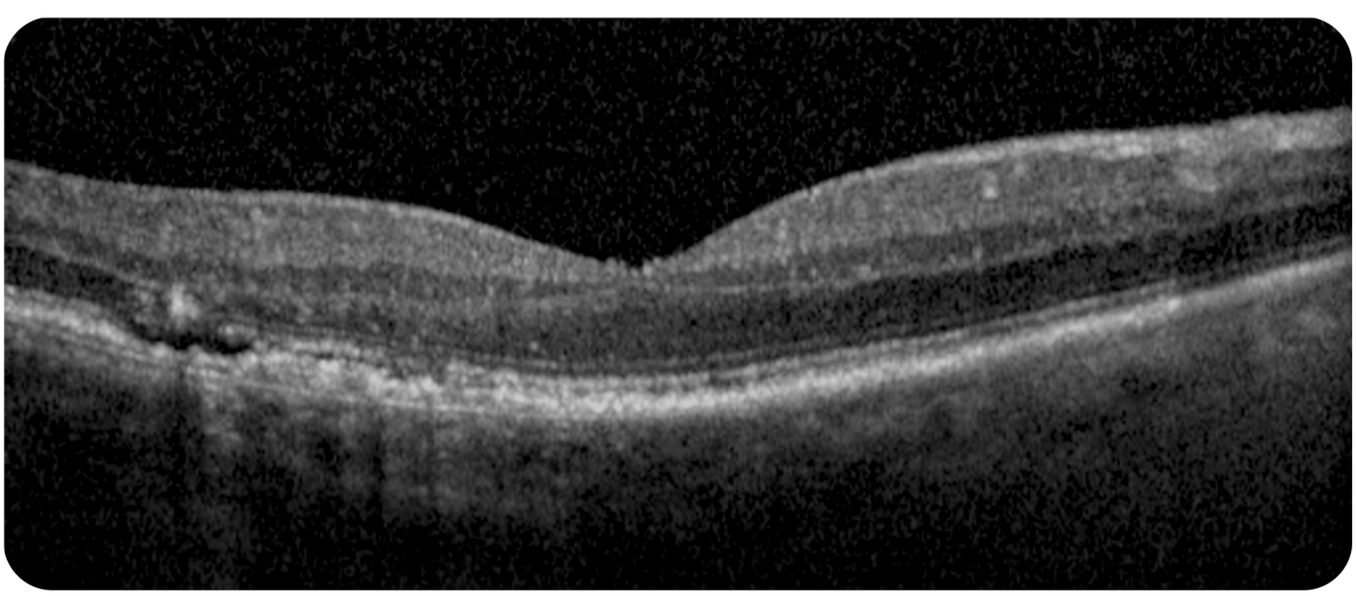
Age 83



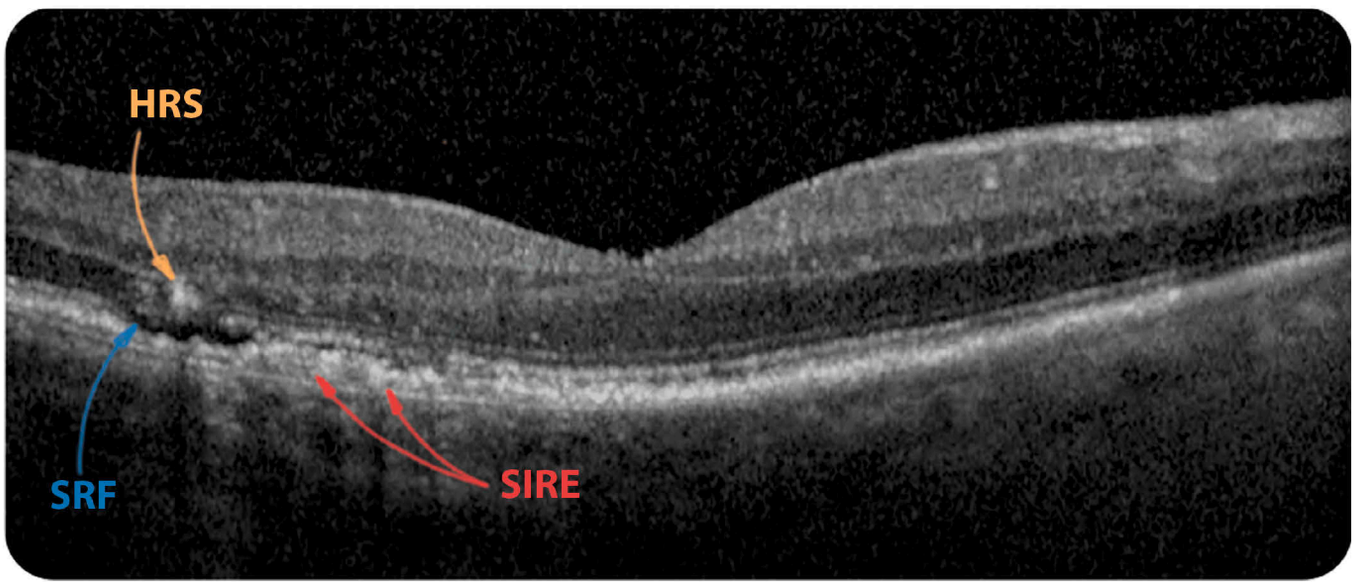
IR Image:
Vignette artifact, irregular appearance of the retina in the left portion of the image.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 71



Findings

Area	Alteration	Description
Sub-RPE	RPE	Irregular, thinned
	SIRE	With DLS
Subretinal	SRF	Exudation
Intraretinal	PR	PR atrophy
	HRS	Associated to RPE alteration and PR atrophy

Interpretation

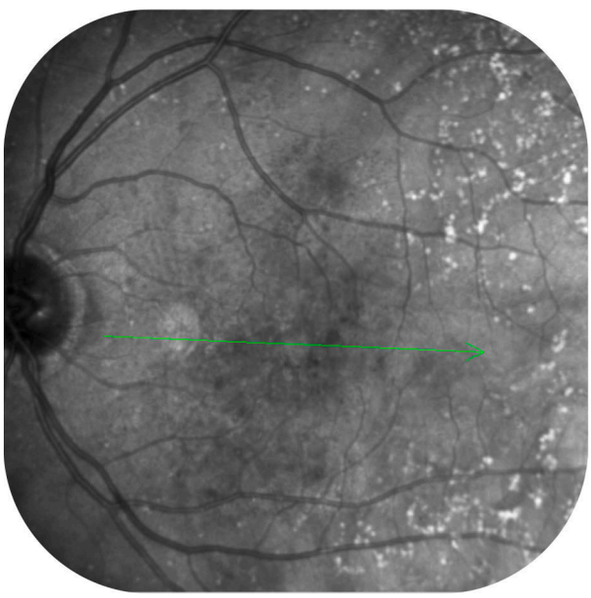
Temporal to the fovea, is a SIRE with a DLS and an associated accumulation of SRF in that area. These findings are consistent with an **active type 1 MNV**. The thick hyperreflective spot above the SRF could represent degenerated retinal tissue.

F-PED: Fibrovascular Pigment Epithelial Detachment – **RPE**: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE Elevation – **DLS**: Double-layer Sign – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **HRS**: Hyperreflective Spots – **MNV**: Macular Neovascularization

Case 72

Case 72

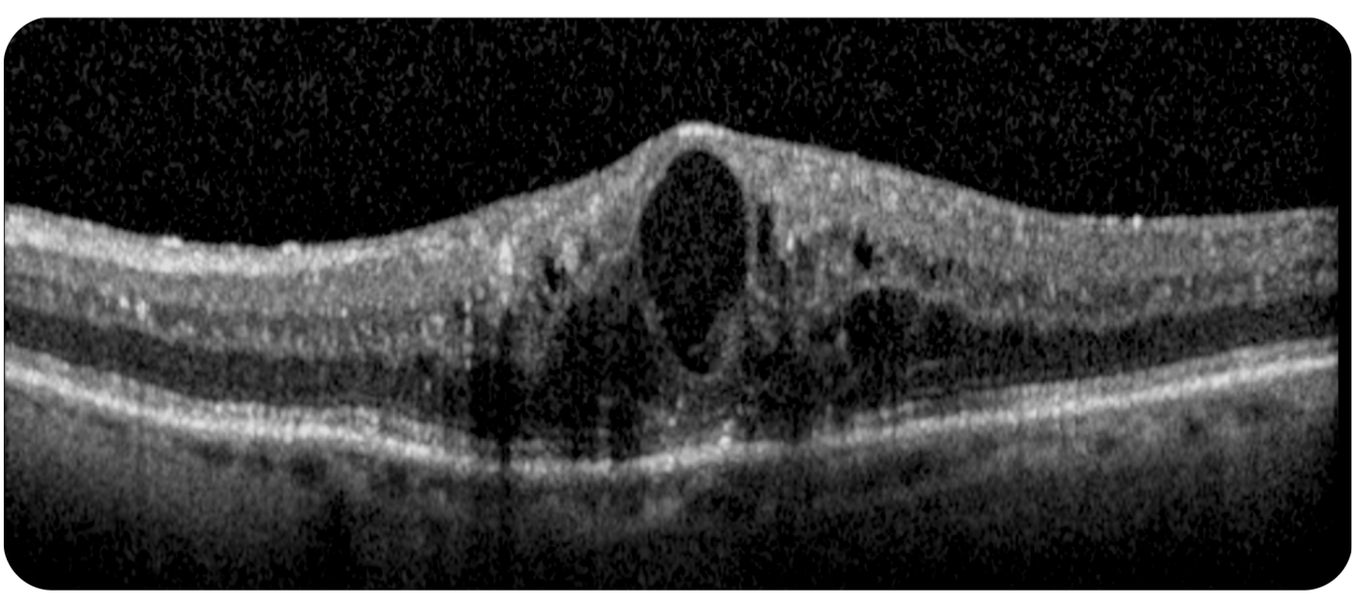
Age 76



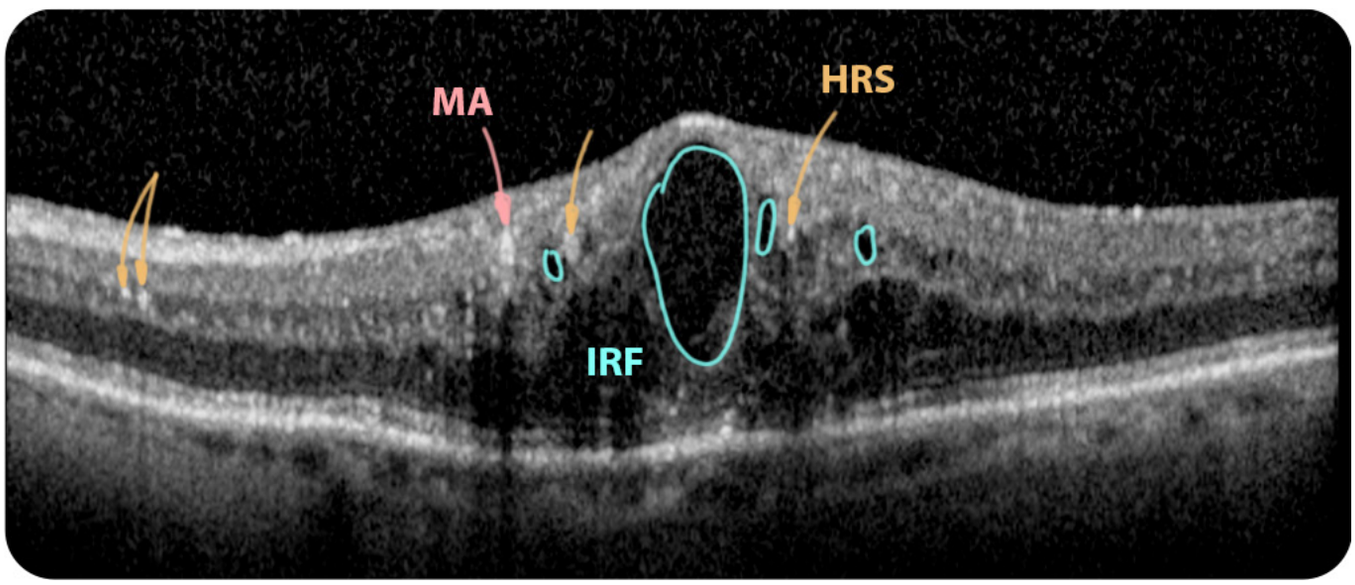
IR Image:
Widespread dark area around the macula. Peripheral hyperreflective spots.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 72



Findings

Area	Alteration	Description
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudates
	IHRM	Microaneurysm
Preretinal	ERM	Thin

Interpretation

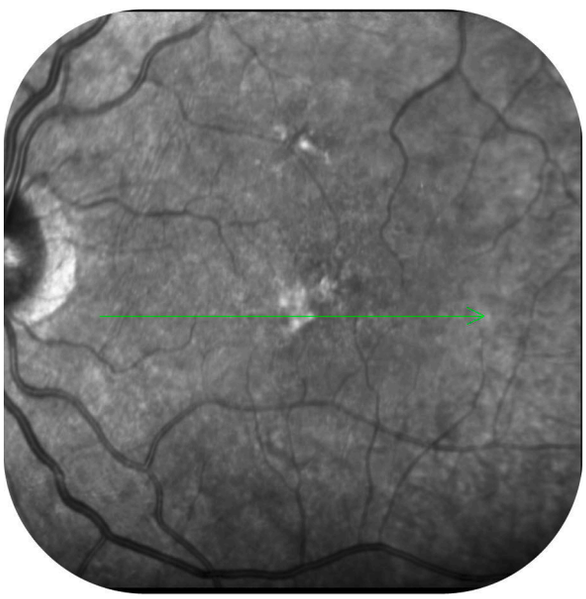
The widespread accumulation of IRF is causing a thickening of the retina and thus, a CME. The microaneurysm and multiple hard exudates are hallmarks of diabetic retinopathy. This patient is very likely suffering from **a diabetic macular edema.** It is important to note that there are multiple areas of signal blockage restricting definite assessment of the EZ.

IRF: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **IHRM**: Intraretinal Hyperreflective Material – **MA**: Microaneurysm - **ERM**: Epiretinal Membrane – **EZ**: Ellipsoid Zone – **CME:** Cystoid Macular Edema

Case 73

Case 73

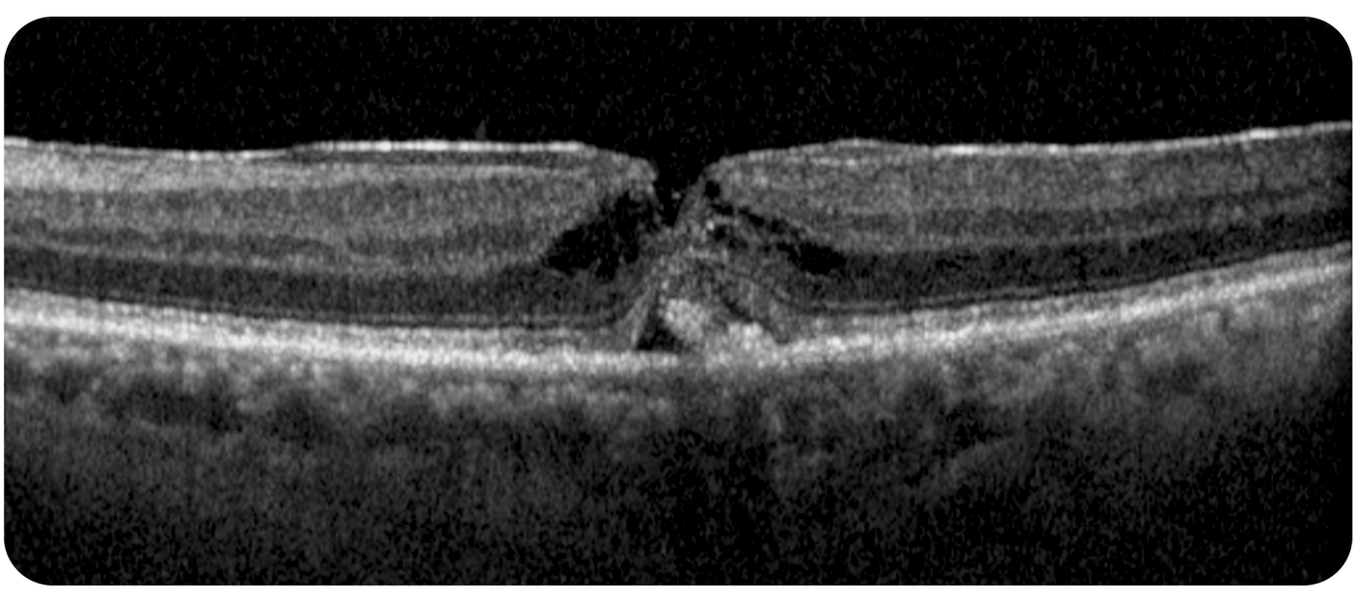
Age 68



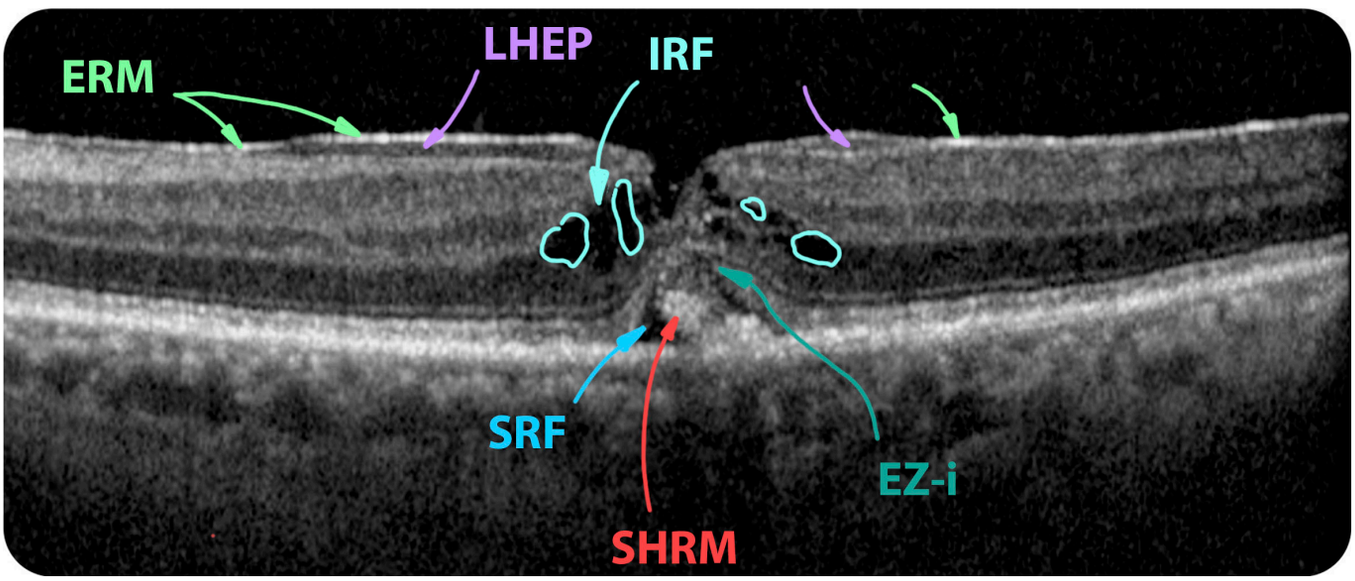
IR Image:
Hyperreflective irregularities around the fovea with an attenuated hyporeflective area and some wrinkles close to the superior vascular arcade can be seen.

Scan Quality:
Good with no artifacts

Location:
Perifovea/fovea



Case 73



Findings

Area	Alteration	Description
Subretinal	RPE	Irregular, clumped
	SRHM	Fuzzy with SRF
	SRF	Associated to RPE alteration
	PR	EZ interrupted
Intraretinal	IRF	Local edema
	RL	Lamellar macular hole
Preretinal	LHEP	Associated to LMH
	ERM	Distinct

Interpretation

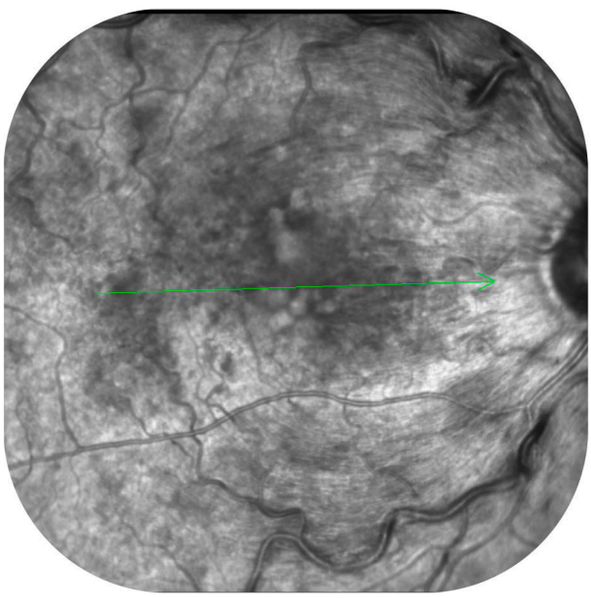
We are looking at an ambiguous case that presents two components. Firstly, there is a suspect **lamellar macular hole** with associated retinal edema. (The ERM and LHEP support the suspect diagnosis of a lamellar macular hole.) Secondly, a suspicious SHRM with SRF needs further diagnostics (OCT-A, FA) to rule out an MNV. As the EZ is interrupted right at the fovea, this patient has a reduced VA-prognosis.

RPE: Retinal Pigment Epithelium – **SRF**: Subretinal Fluid – **SHRM**: Subretinal Hyperreflective Material – **EZ:** Ellipsoid Zone – **EZ-i:** Ellispoid Zone Interruption – **SRF**: Subretinal Fluid – **PR**: Photoreceptor – **IRF**: Intraretinal Fluid – **RL**: Retinal Layers – **LHEP**: Lamellar Hole-associated Epiretinal Proliferation – **ERM**: Epiretinal Membrane

Case 74

Case 74

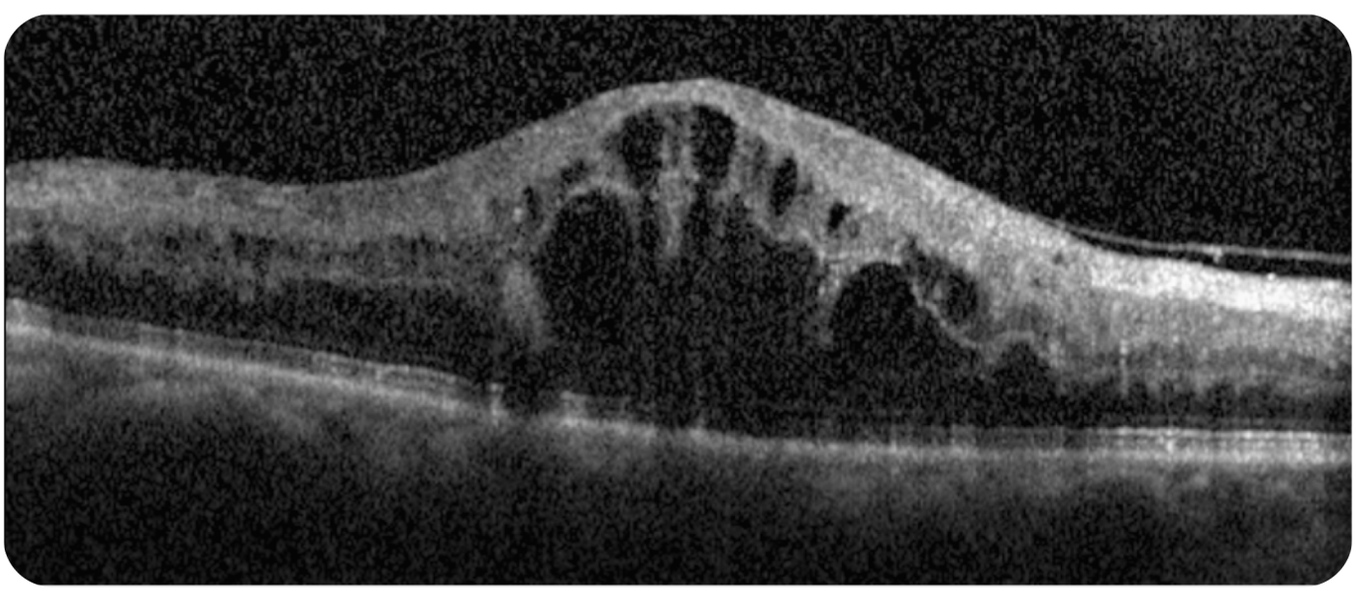
Age 64



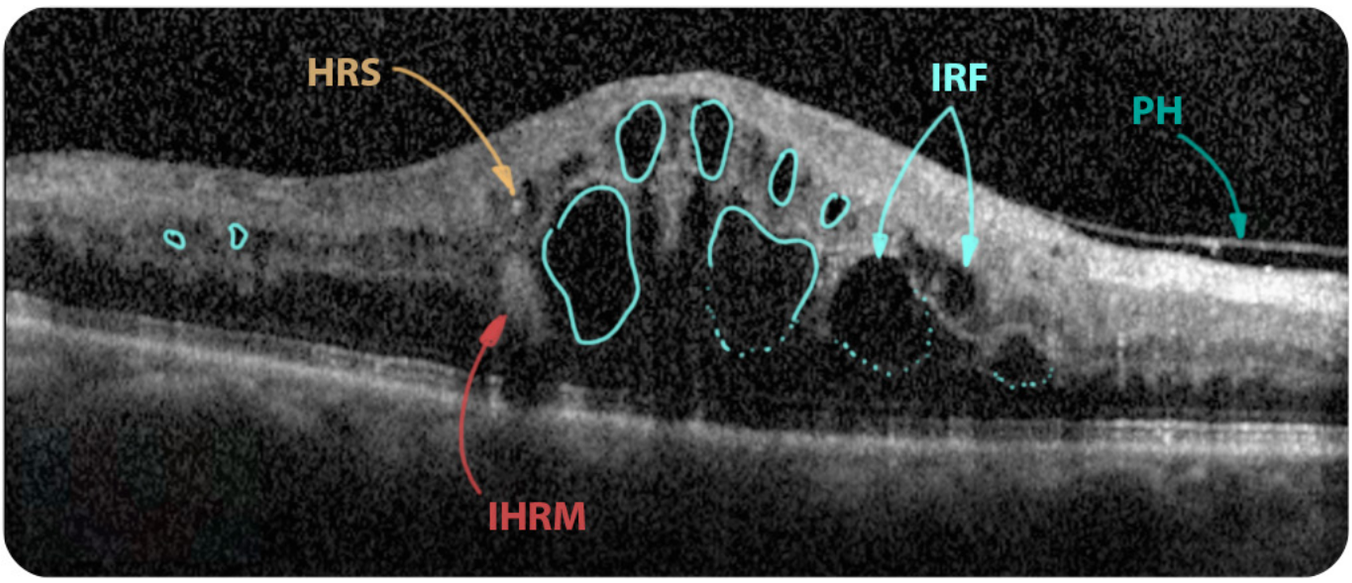
IR Image:
The foveal and perifoveal area has a hyporeflective appearance, most likely due to fluid accumulation. The veins appear tortuous.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 74



Findings

Area	Alteration	Description
Intraretinal	IRF	Widespread
	HRS	Exudate
	IHRM	Hemorrhage
Preretinal	PH	Posterior hyaloid

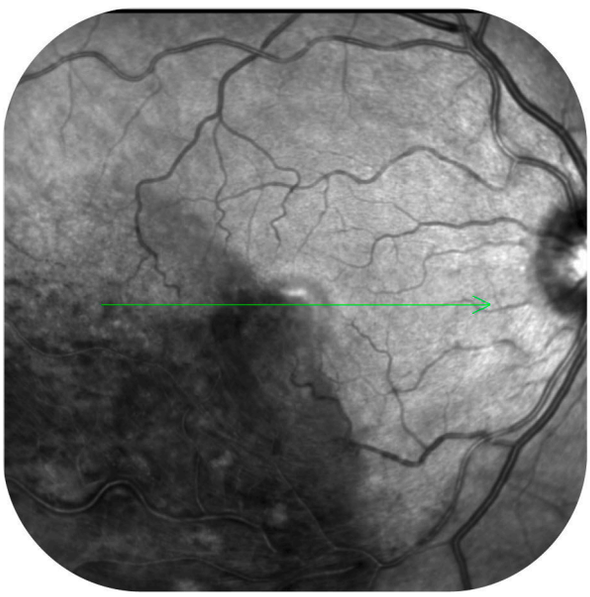
Interpretation

The most striking feature of this scan is the CME resulting from a widespread accumulation of IRF. The tiny HRS could be a sign of a beginning lipid exudation and thus blood retinal barrier breakdown. The IRHM below the cystic spaces likely represents an intraretinal hemorrhage with adjacent signal blockage. The hyperreflective appearance of the inner retinal layers on the right side of the scan could be indicating ischemia. In conjunction, with the findings from the IR image a **CME secondary to a CRVO with artery flow impairment** could be the basis for further diagnostics. The EZ might present irregularly, however, there are multiple areas of signal blockage restricting definite assessment of the EZ.

IRF: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **IHRM**: Intraretinal Hyperreflective Material – **PH**: Posterior Hyaloid – **CME**: Cystoid Macular Edema – **CRVO**: Central Retinal Vein Occlusion – **EZ:** Ellipsoid Zone

Case 75

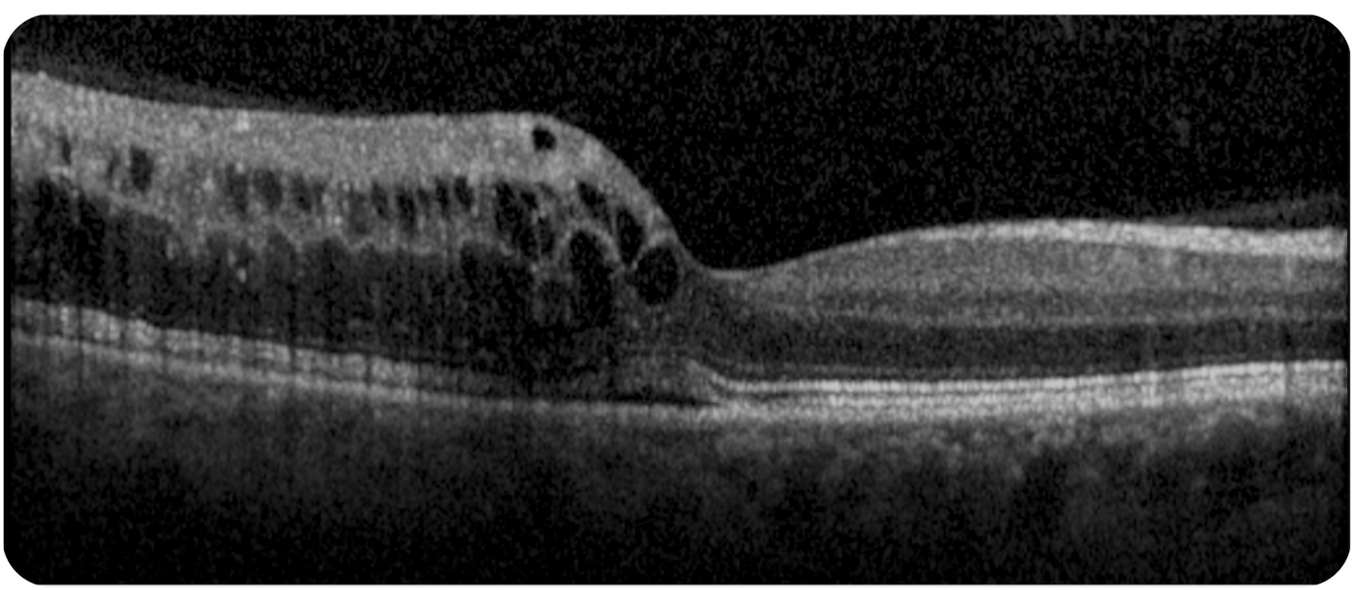
Age 64



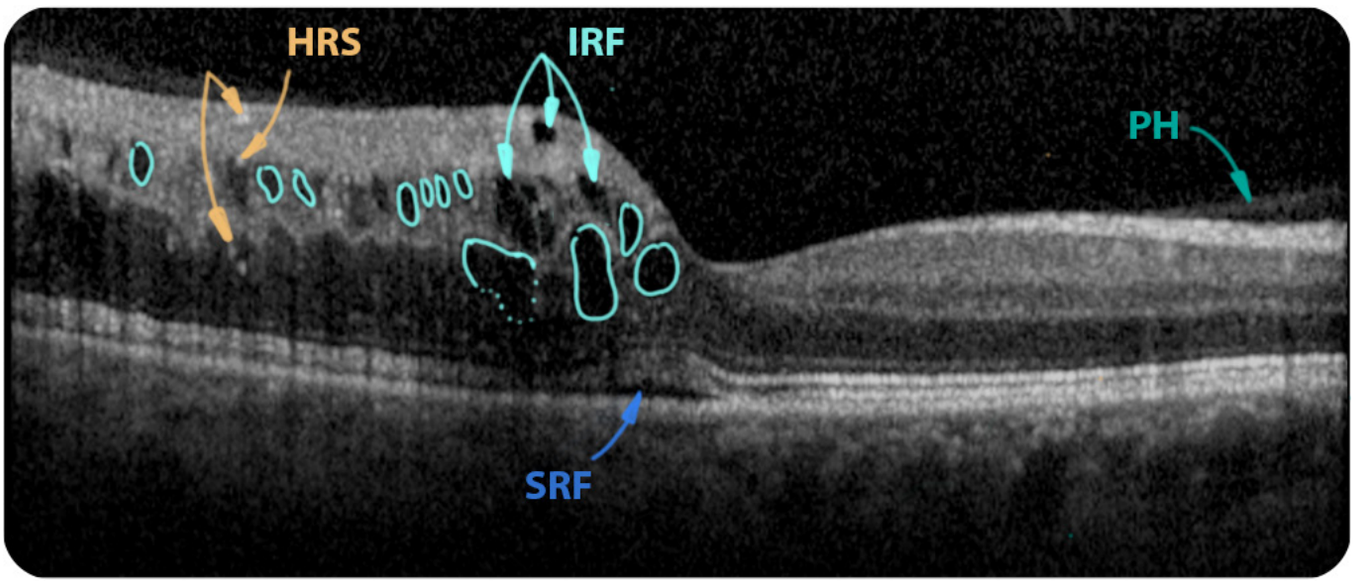
IR Image:
The inferior temporal quadrant has a very dark appearance likely due to fluid accumulation, and the inferior temporal branch vein appears tortuous.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 75



Findings

Area	Alteration	Description
Sub-retinal	SRF	Associated to CME
Intraretinal	IRF	Causing retinal thickening
	HRS	Exudates
Preretinal	PH	Posterior hyaloid

Interpretation

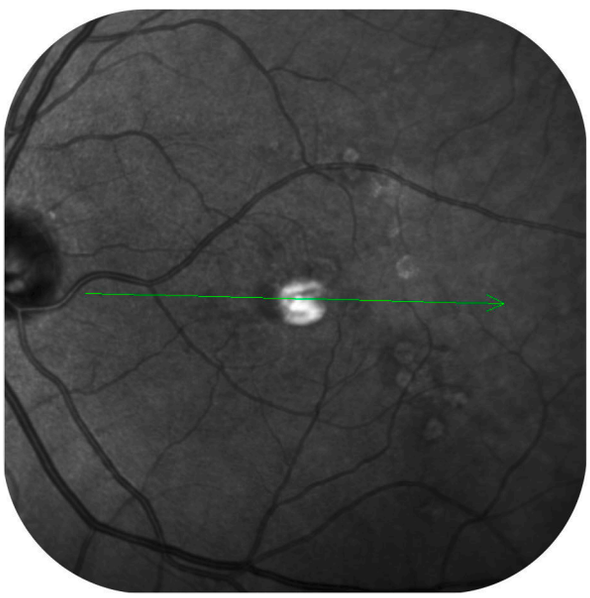
We are looking at a patient with a CME and an associated accumulation of SRF. Numerous HRS most likely represent lipid exudates, thus indicating a retinal vascular disease. In conjunction with the findings in the IR image, this patient likely has a **CME secondary to a BRVO**.

SRF: Subretinal Fluid – **CME**: Cystoid Macular Edema – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **PH**: Posterior Hyaloid – **CME**: Cystoid Macular Edema – **BRVO**: Branch Retinal Vein Occlusion

Case 76

Case 76

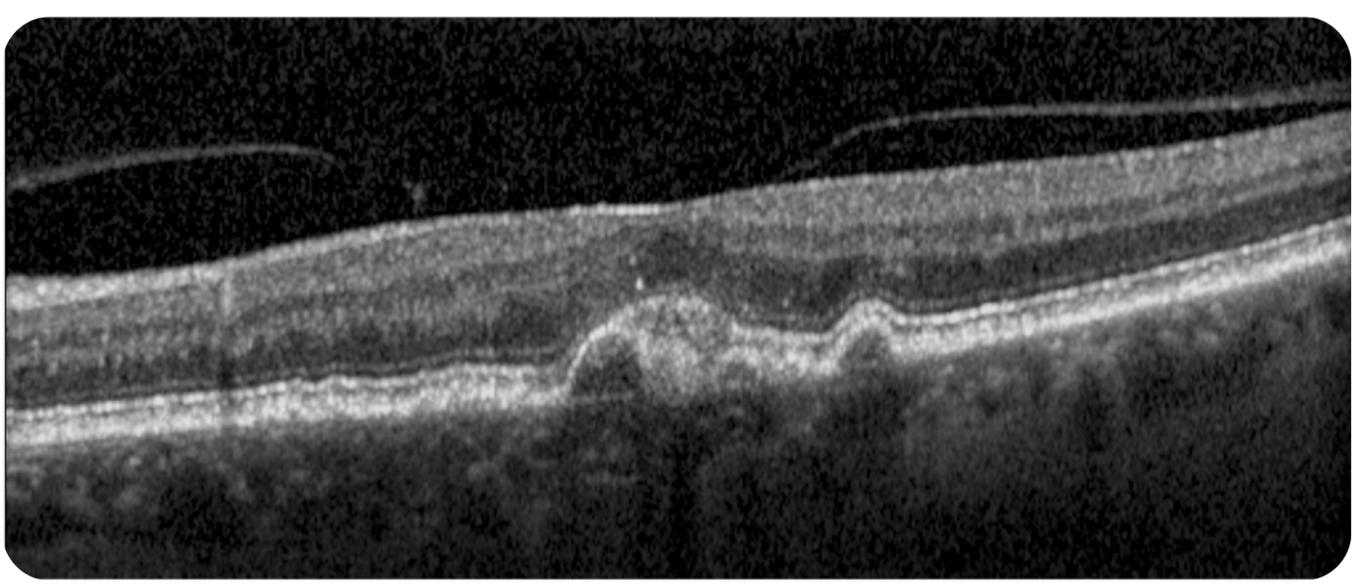
Age 74



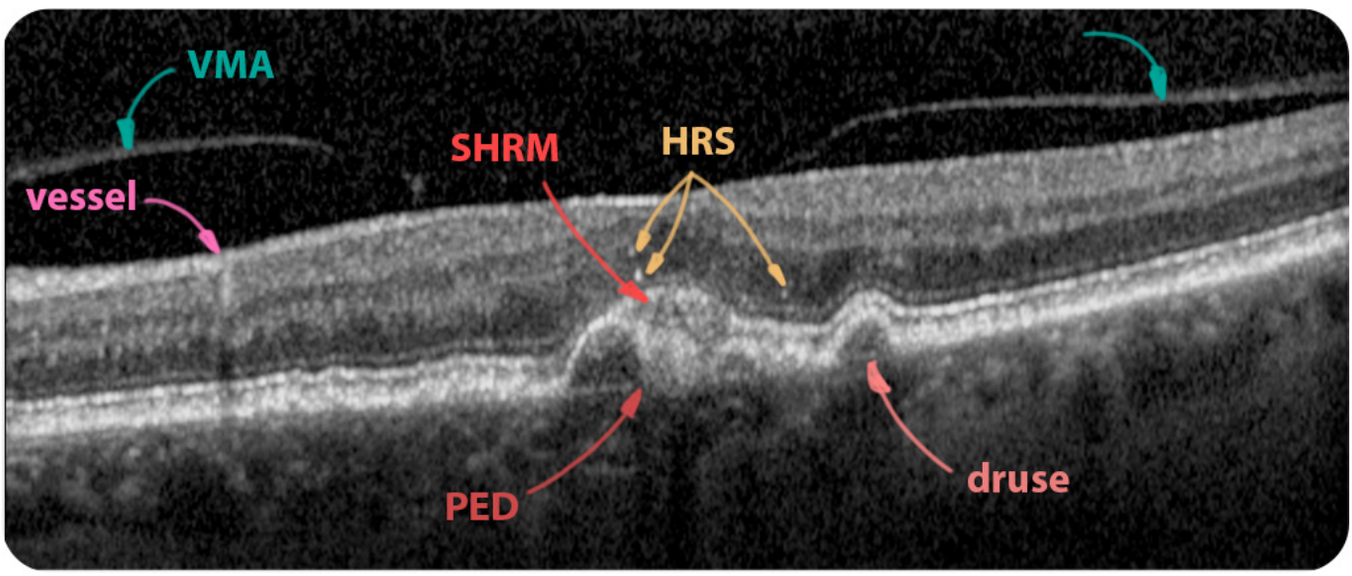
IR Image:
Irregular appearance of the macula; the inferior temporal retinal artery is taking an unusual course, and there are multiple bright areas temporally.

Scan Quality:
Good with no artifacts

Location:
Periphery



Case 76



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Hypo- and hyperreflective PED; druse
Subretinal	SHRM	Uncertain SHRM without SRF
Intraretinal	HRS	Associated to RPE alteration
Preretinal	VMA	

Interpretation

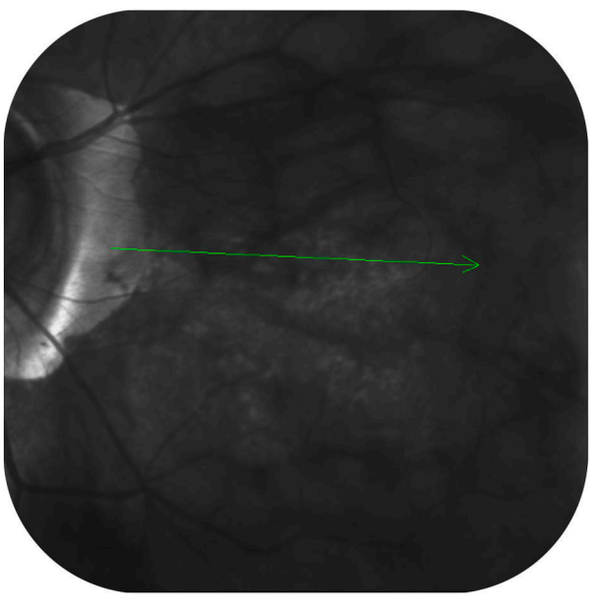
The central PED has a hypo- and a hyperreflective component that is in part drusenoid but also suspect to a fibrovascular process. There is associated suspect SHRM, however, without SRF. Thus, it is an ambiguous case that would need further investigation (e.g., OCT-A, FA). The HRS are associated with an alteration of the RPE and could represent migrated pigment cells. This patient has **AMD**.

RPE: Retinal Pigment Epithelium – **PED**: Pigment Epithelial Detachment – **SHRM**: Subretinal Hyperreflective Material – **SRF**: Subretinal Fluid – **HRS**: Hyperreflective Spots – **VMA**: Vitreomacular Adhesion – **OCT-A:** Optical Coherence Tomography Angiography – **FA**: Fluorescein Angiography – **AMD:** Age-related Macular Degeneration

Case 77

Case 77

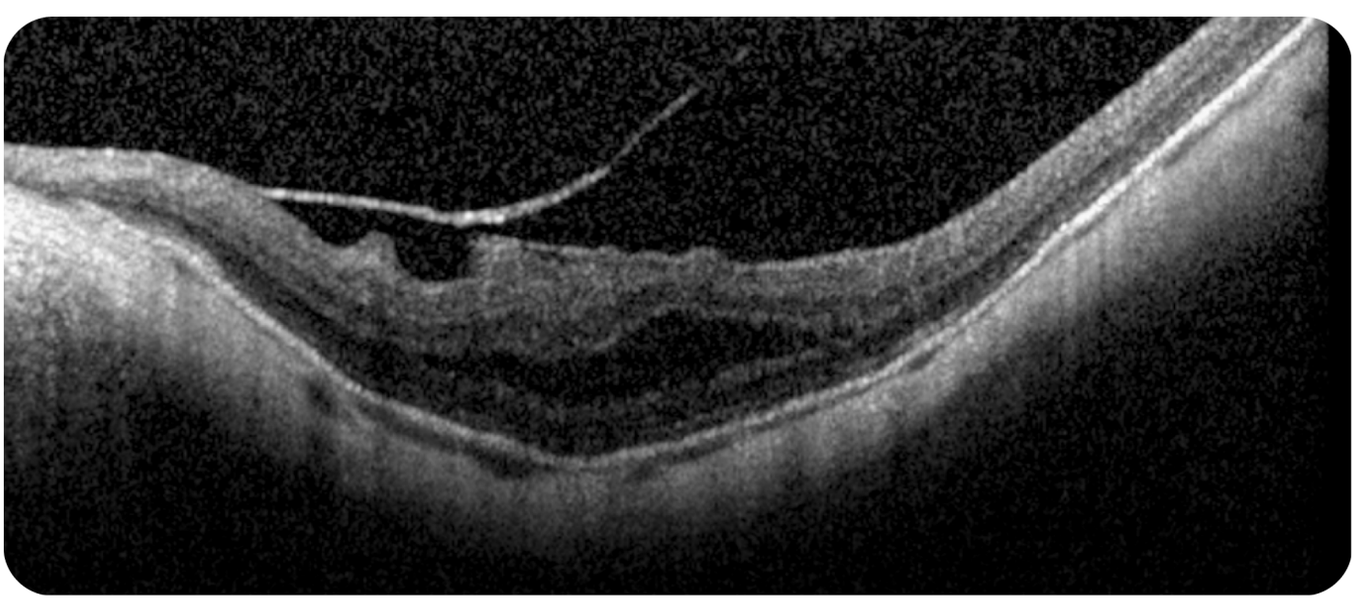
Age 46



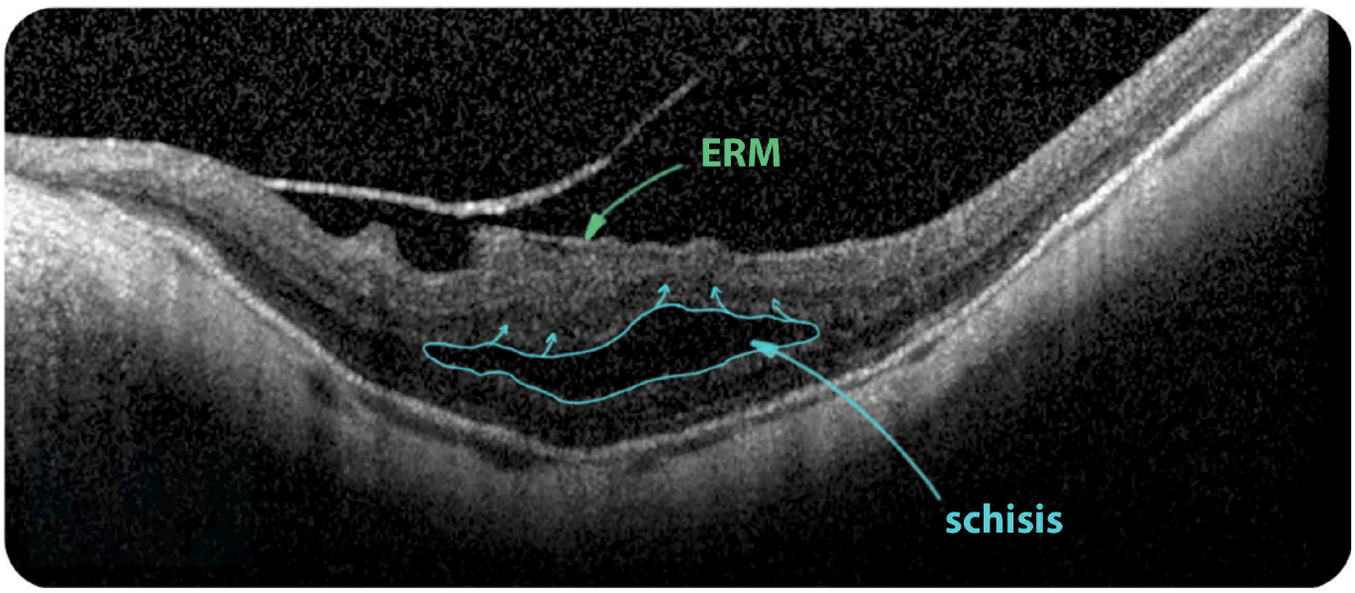
IR Image:
This very dark image is difficult to assess. Peripapillary chorioretinal atrophy is visible.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 77



Findings

Area	Structure	Description
Intraretinal	Layers	Dissociated layers between ONL and OPL
Preretinal	ERM	Thin
	Vitreous	Posterior hyaloid

Interpretation

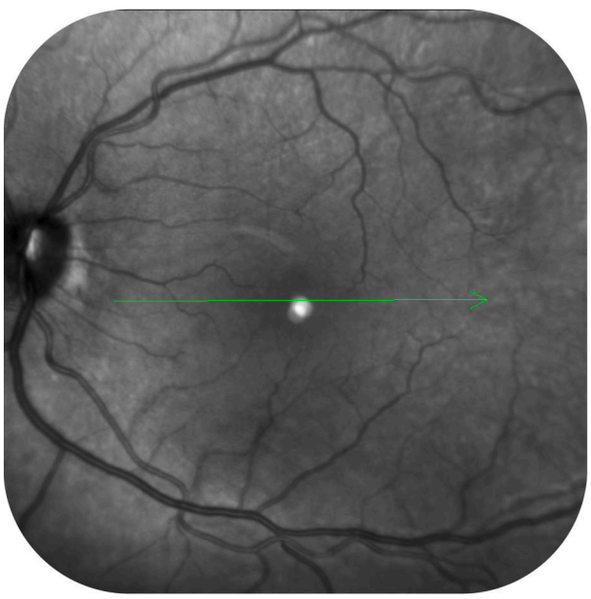
This patient's retinal layers are dissociated between the ONL and OPL with an accumulation of IRF. There is a thin ERM, and the hyperreflective band likely represents the posterior vitreous. An extremely thin choroid, is often present in highly myopic eyes. This patient is most likely suffering from a **myopic foveoschisis** – the outward bulging is consistent with a **staphyloma**.

ONL: Outer Nuclear Layer – **OPL**: Outer Plexiform Layer – **ERM**: Epiretinal Membrane – **IRF:** Intraretinal Fluid

Case 78

Case 78

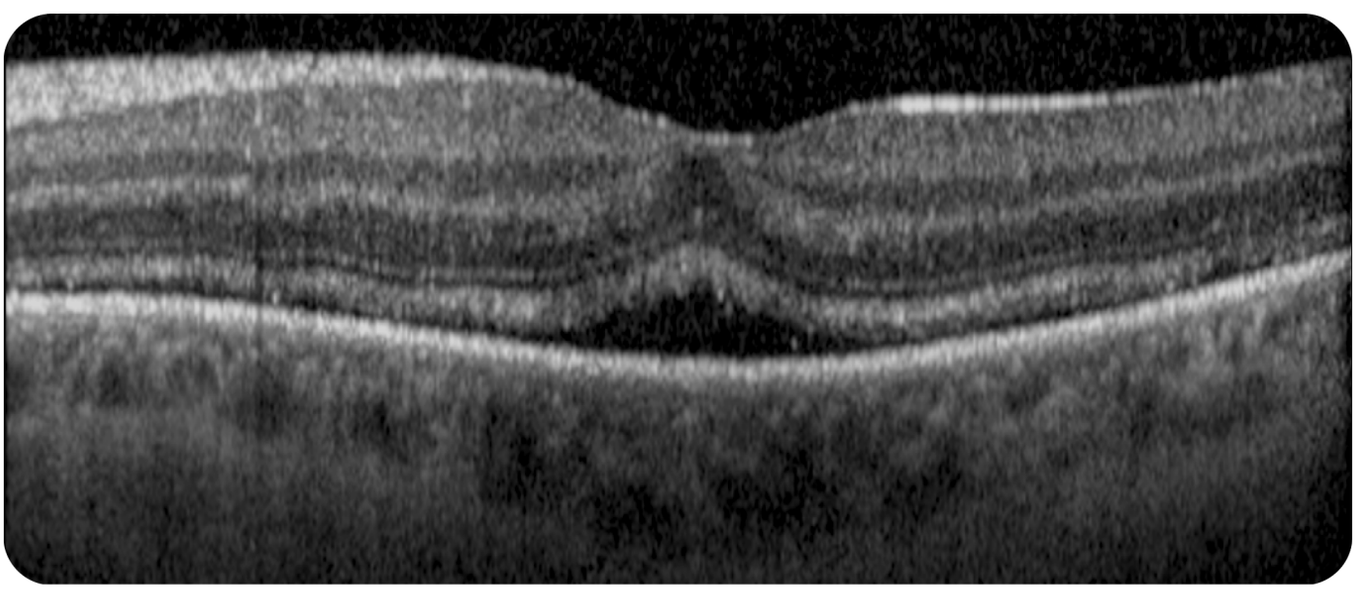
Age 62



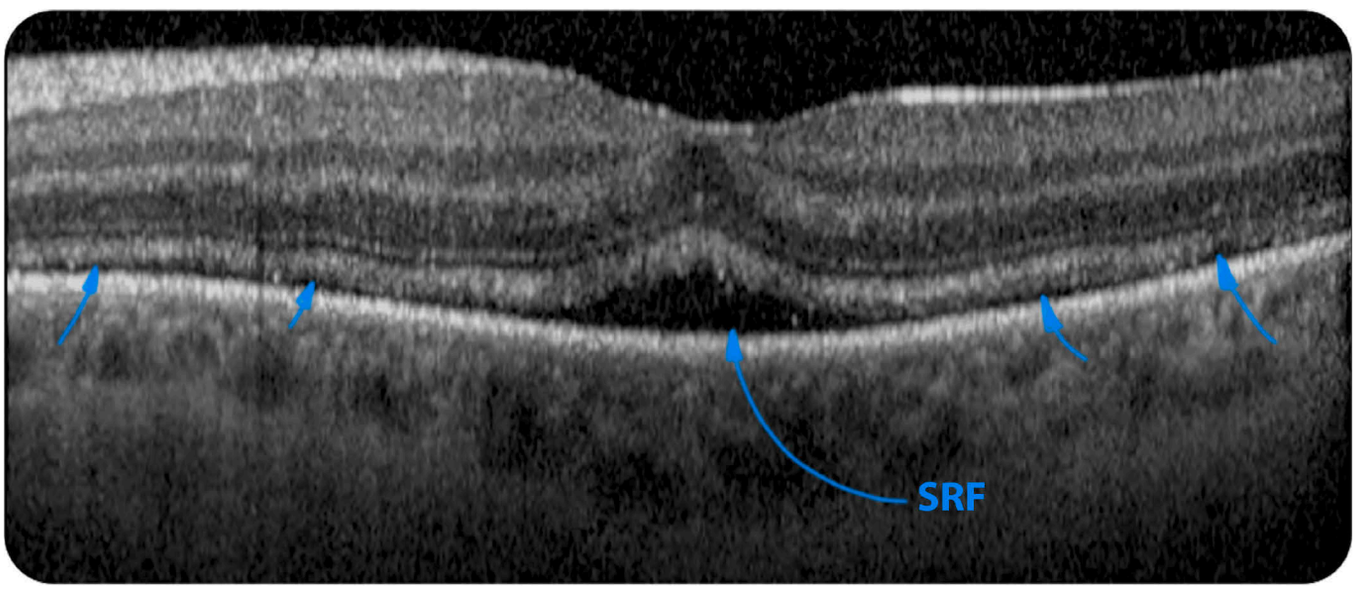
IR Image:
The perifoveal area appears a little darker than the rest of the fundus. Central light reflex artifact.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 78



Findings

Area	Alteration	Description
Subretinal	SRF	Widespread SRF accumulation
Preretinal	ERM	Thin

Interpretation

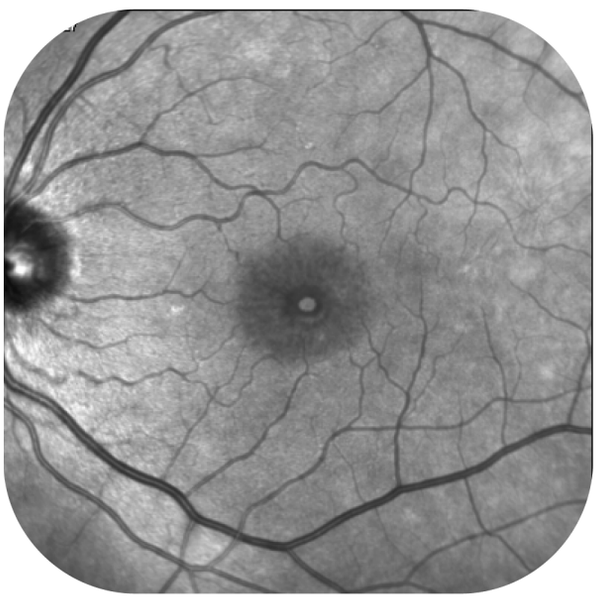
This patient has a widespread accumulation of SRF - we are looking at a shallow **macula-off retinal detachment**.

SRF: Subretinal Fluid – **ERM**: Epiretinal Membrane

Case 79

Case 79

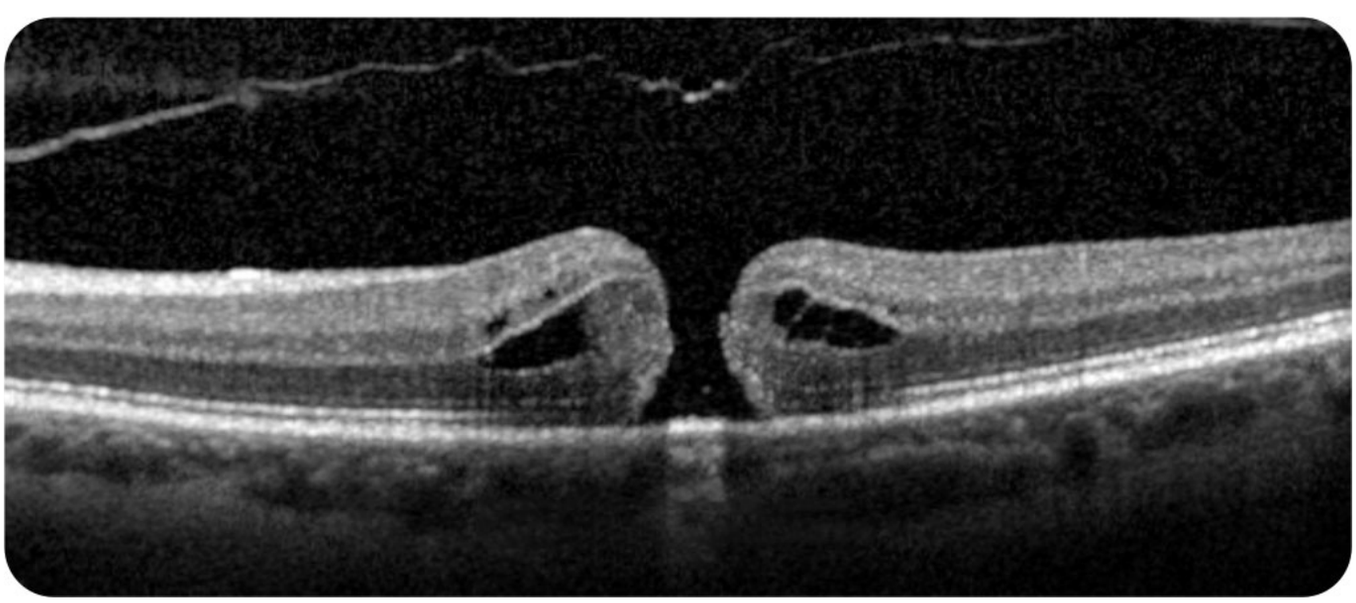
Age 64



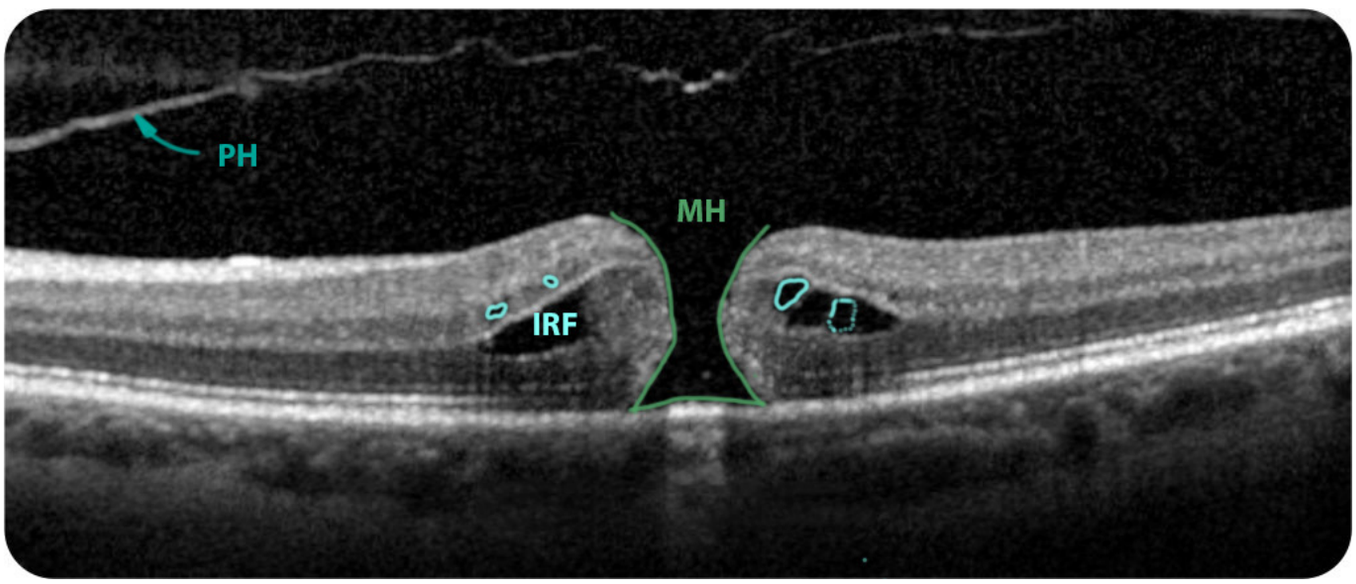
IR Image:
A volcano-like appearance of the foveal area.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 79



Findings

Area	Alteration	Description
Subretinal	PR	EZ and PR disrupted
Intraretinal	IRF	Associated to FTMH
Preretinal	MH	Full thickness macular hole

Interpretation

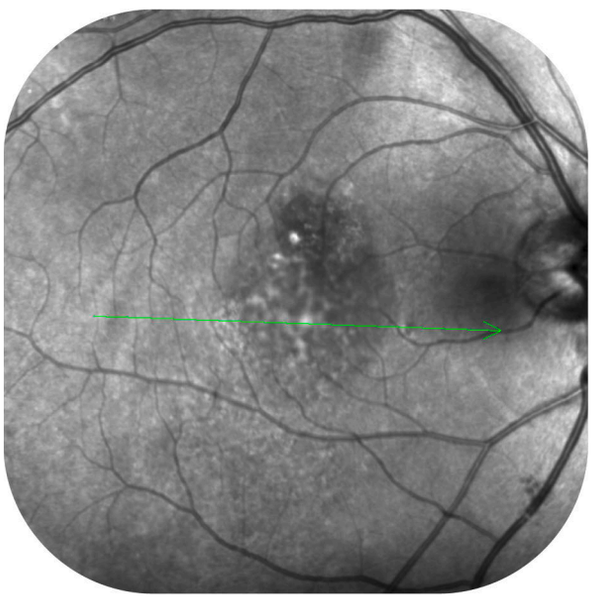
The most striking feature of this eye is the **full-thickness macular hole** with a complete disruption of all retinal layers down to the RPE. It is accompanied by an accumulation of IRF on both sides of the hole. Additionally, the posterior hyaloid is visible.

PR: Photoreceptors – **EZ**: Ellipsoid Zone – **FTMH**: Full Thickness Macular Hole – **MH**: Macular Hole – **IRF**: Intraretinal Fluid – **PH**: Posterior Hyaloid – **RPE:** Retinal Pigment Epithelium

Case 80

Case 80

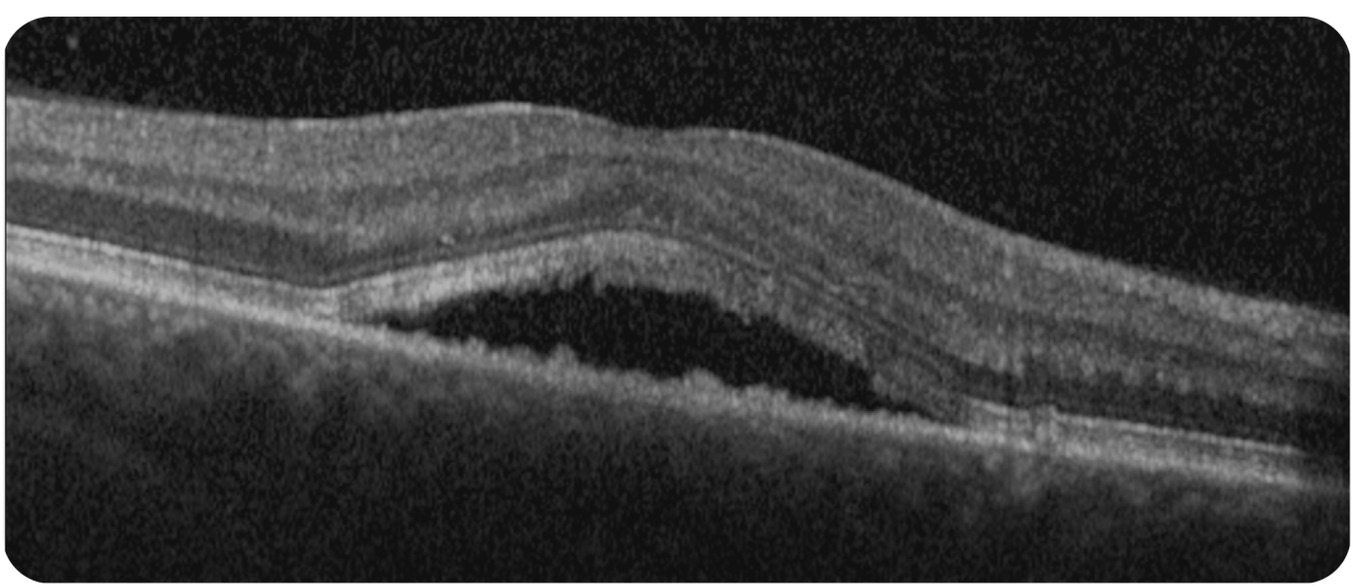
Age 44



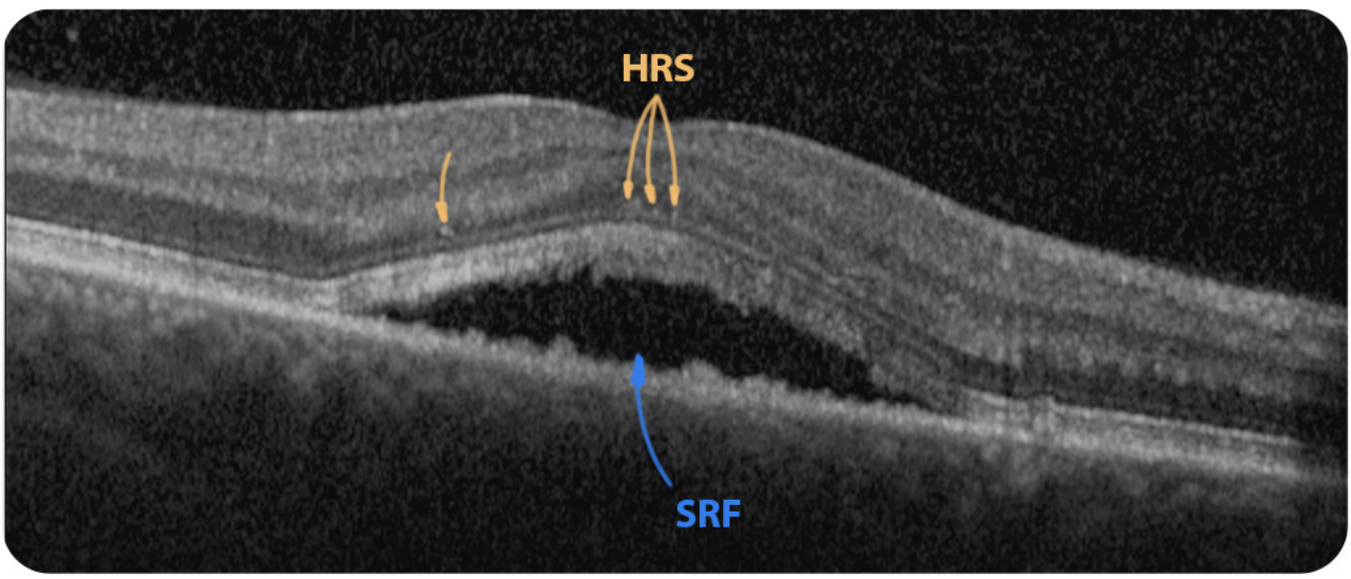
IR Image:
The fovea and perifoveal areas have a hyporeflective appearance with an irregular hyperreflective formation above them.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 80



Findings

Area	Alteration	Description
Subretinal	SRF	SRF accumulation
Intraretinal	HRS	Around the ELM

Interpretation

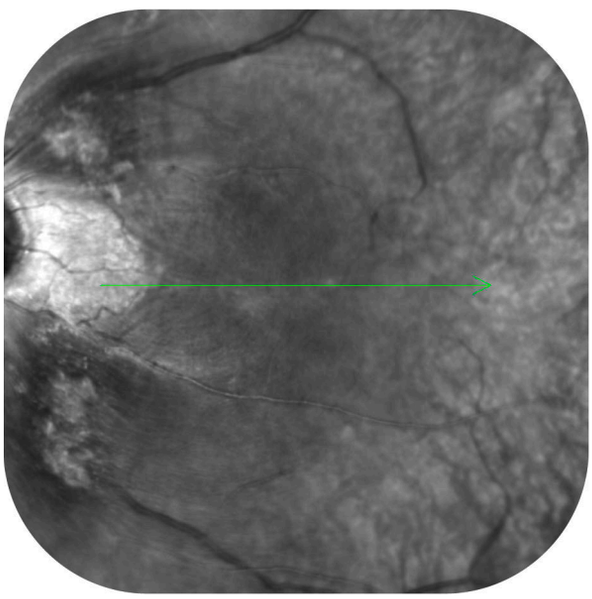
There is a significant amount of SRF without a definite site of origin. The HRS around the ELM could be first signs of retinal degeneration. There are subretinal deposits, that likely do not represent SDD as this patient is relatively young. Enhanced depth imaging would allow us to visualize a thickened choroid, as this patient is **suspect to CSC**.

SRF: Subretinal Fluid – **HRS**: Hyperreflective Spots – **ELM**: External Limiting Membrane – **SDD**: Subretinal Drusenoid Deposits – **CSC:** Central Serous Chorioretinopathy

Case 81

Case 81

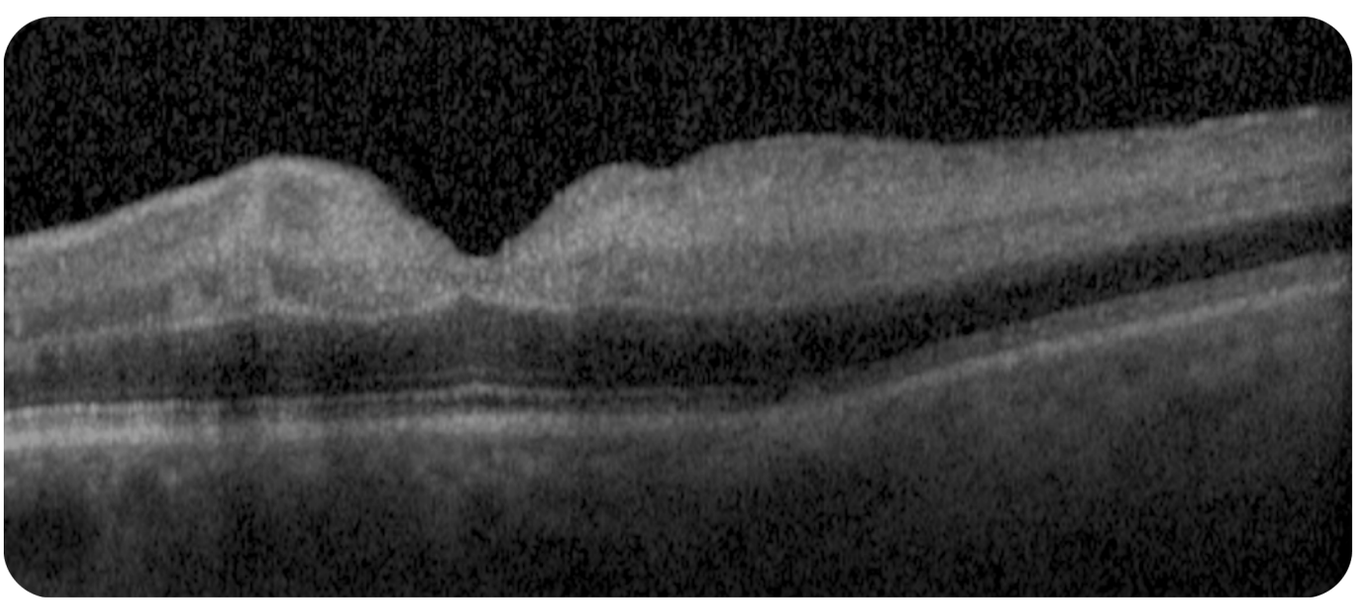
Age 79



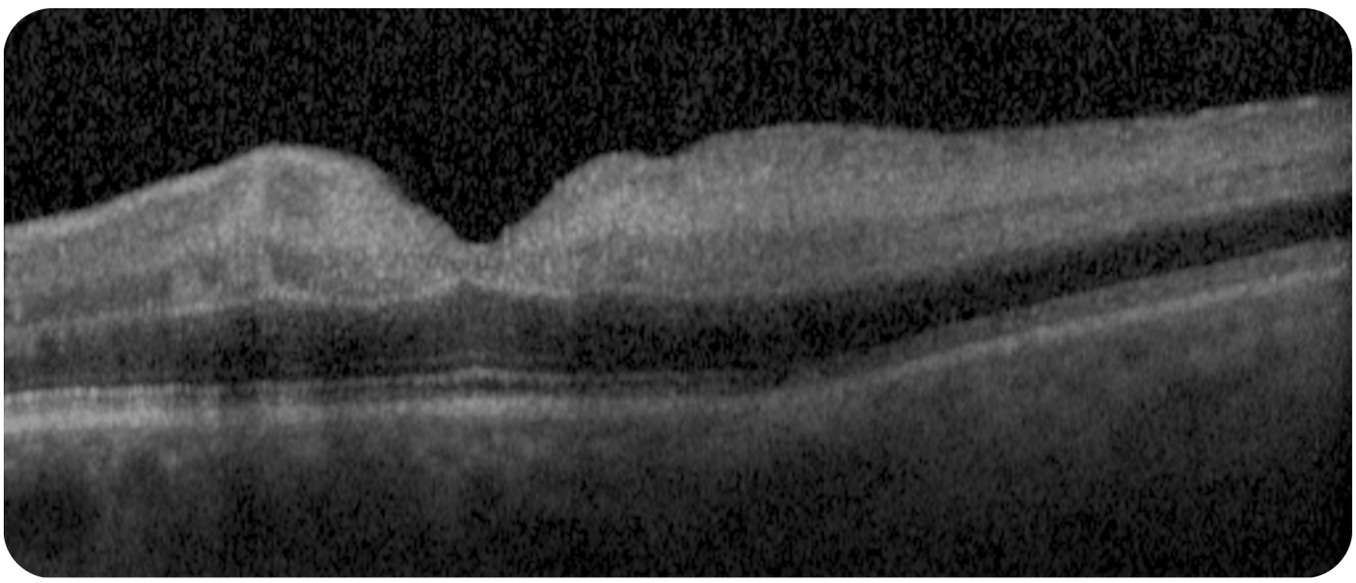
IR Image:
Diffusely blurred IR image

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 81



Findings

Area	Structure	Description
Intraretinal	IRL	Hyperreflective inner retinal layer

Interpretation

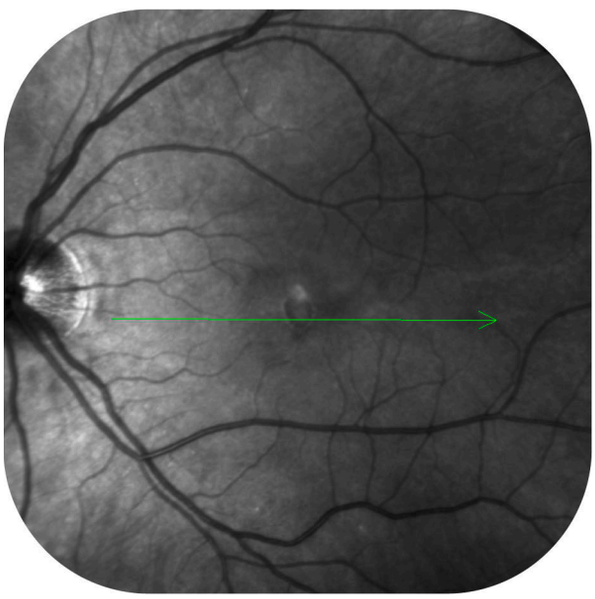
This scan shows increased reflectivity and swelling of the inner retinal layers - a picture consistent with **retinal ischemia due to a retinal artery occlusion.**

IRL: Inner Retinal Layers

Case 82

Case 82

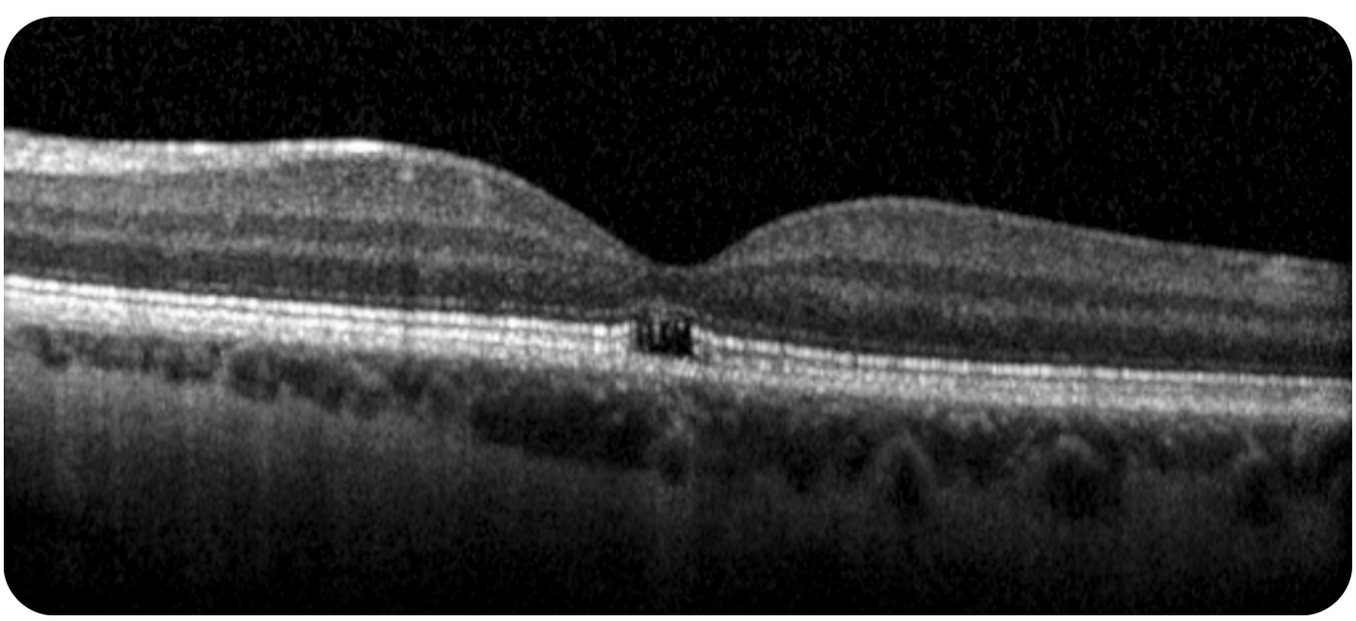
Age 26



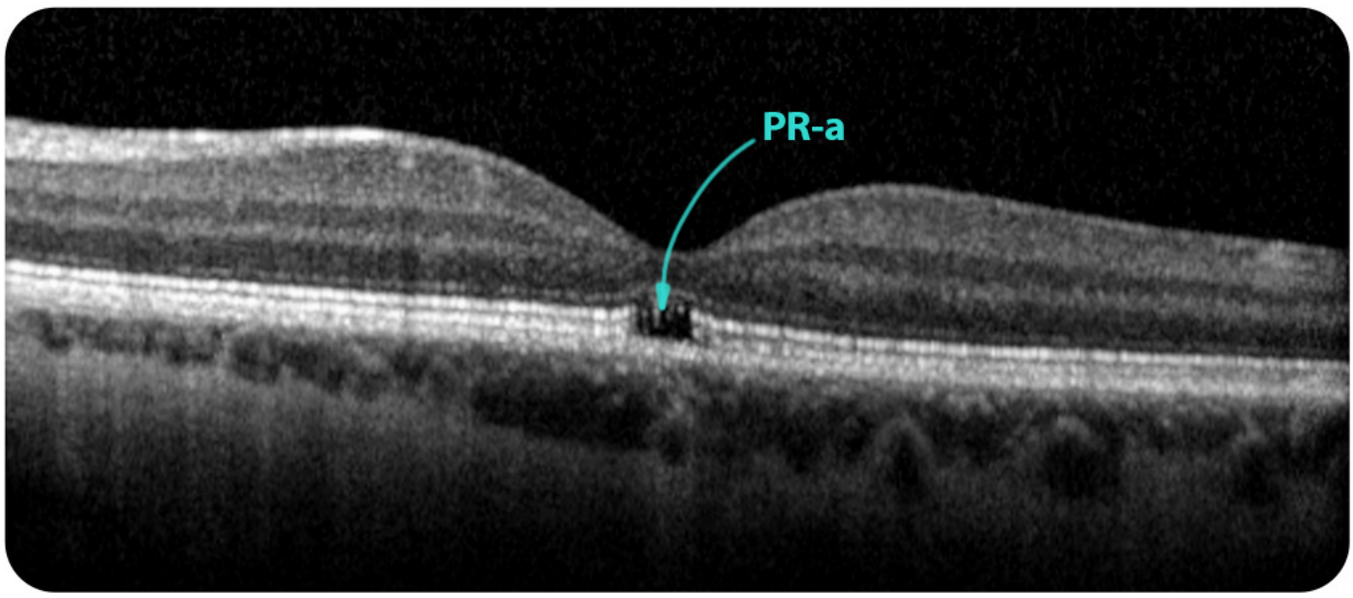
IR Image:
Hyporeflective center surrounded by a thin hyperreflective halo and a medium reflective spot at 12 o'clock.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 82



Findings

Area	Structure	Description
Subretinal	PR	EZ and PR atrophy (micro hole)

Interpretation

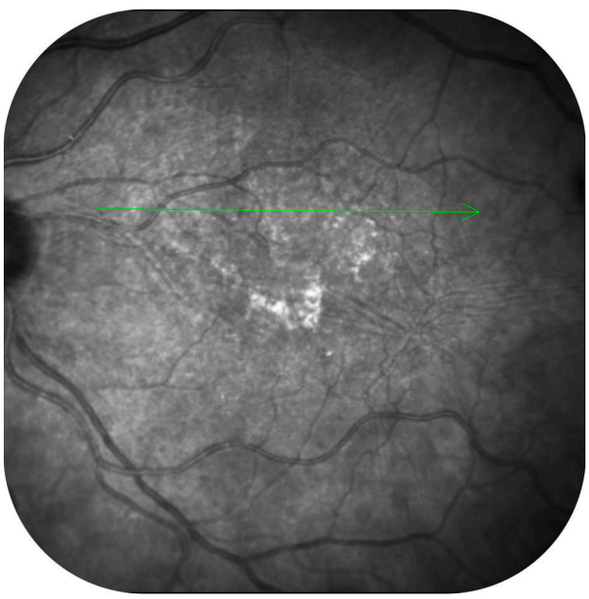
There is focused and isolated atrophy of the PRs (micro hole), sparing the remaining layers. This patient is suffering from **solar retinopathy** after an accident with a strong laser pointer.

PR: Photoreceptors – **PR-a:** Photoreceptor Atrophy – **EZ**: Ellipsoid Zone

Case 83

Case 83

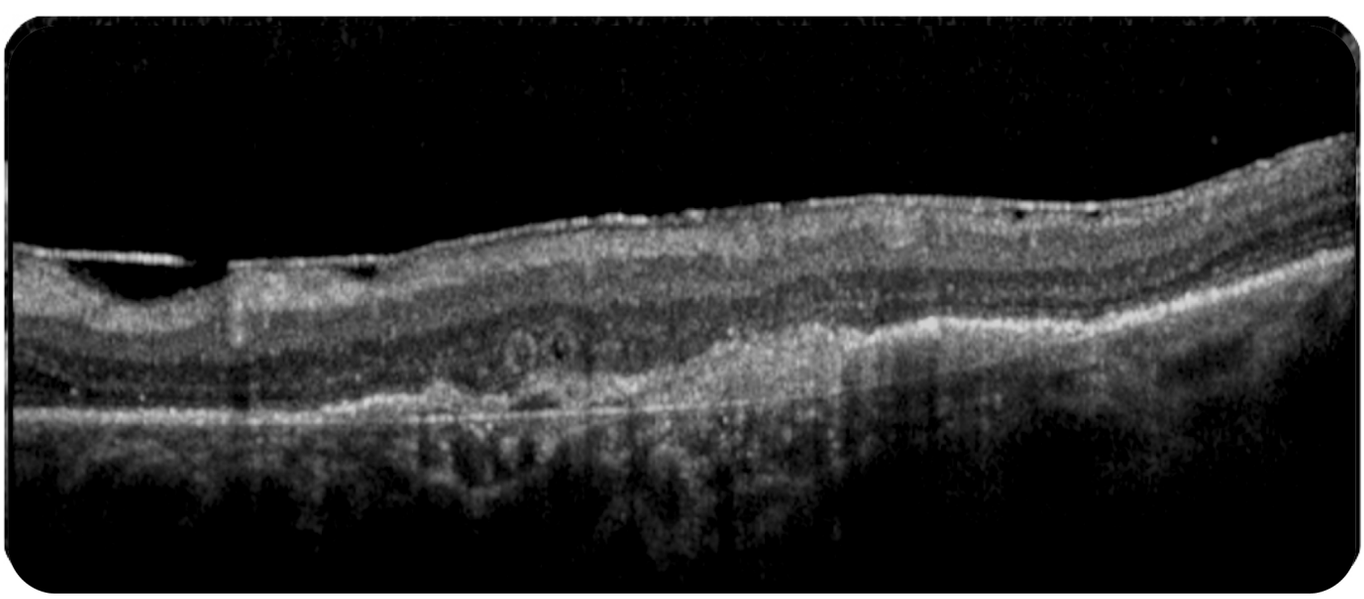
Age 68



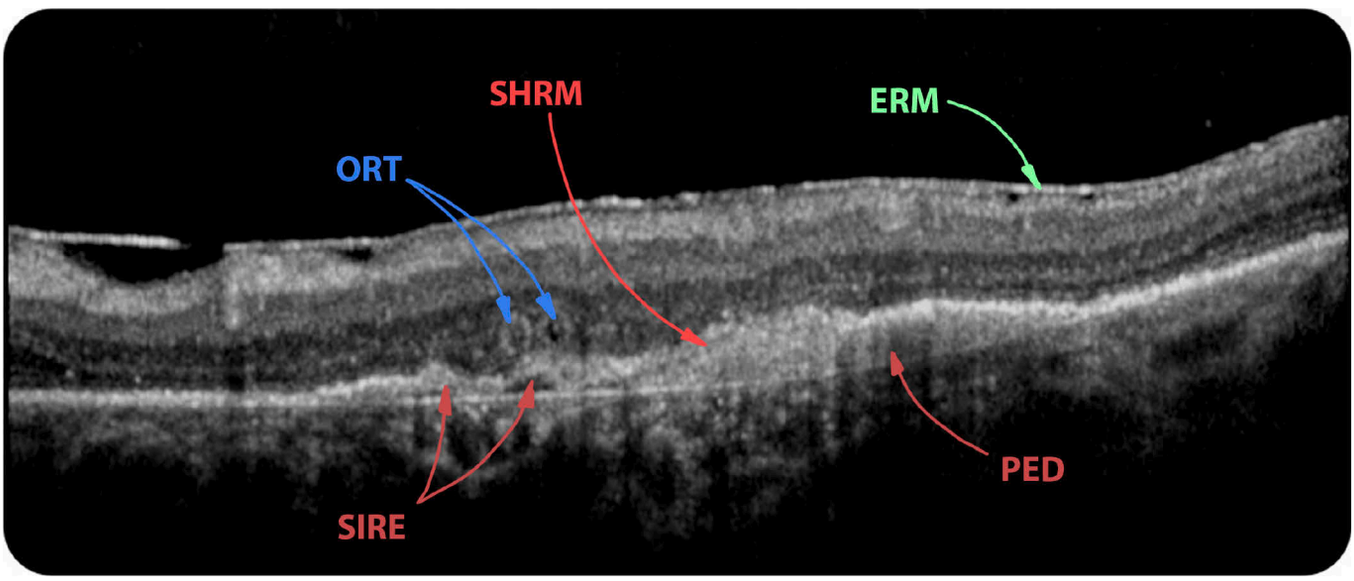
IR Image:
Hyperreflective area inferior to the fovea consistent with scar tissue. The wrinkled appearance is indicative of an ERM.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 83



Findings

Area	Alteration	Description
Sub-RPE	RPE	Irregular, elevated, atrophic
	PED	Drusenoid/Fibrovascular
	SIRE	With DLS
Subretinal	SHRM	Fuzzy, medium reflective
	PR	Atrophy, ORT
Epiretinal	ERM	

Interpretation

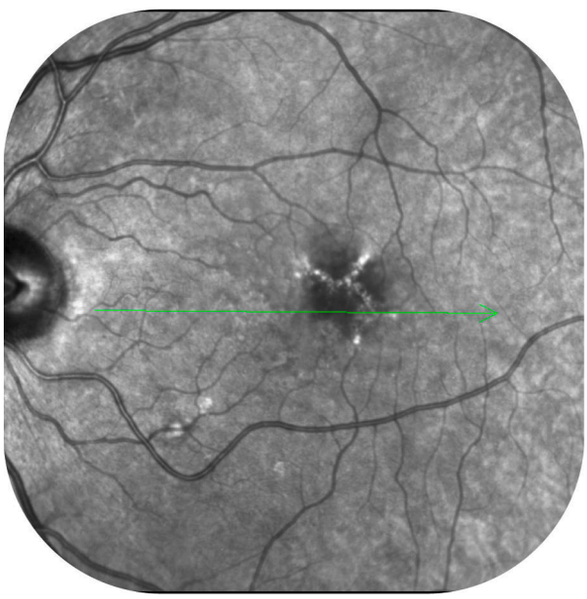
This eye presents a SIRE with a distinct DLS, which is highly suspicious for an MNV. The SHRM is medium reflective, not yet a scar, possibly representing **matured fibrovascular material** without substantial leakage. There is RPE and PR atrophy above the SHRM – in conjunction with the **ORT**, it is indicative of a longstanding, stable disease state, without active leakage. Additionally, there is an **ERM** that is only mildly affecting the underlying retina.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **SIRE:** Shallow Irregular RPE elevation – **DLS:** Double-layer Sign – **SHRM:** Subretinal Hyperreflective Material – **PR:** Photoreceptor – **ORT:** Outer Retinal Tubulation – **ERM:** Epiretinal Membrane – **MNV:** Macular Neovascularization

Case 84

Case 84

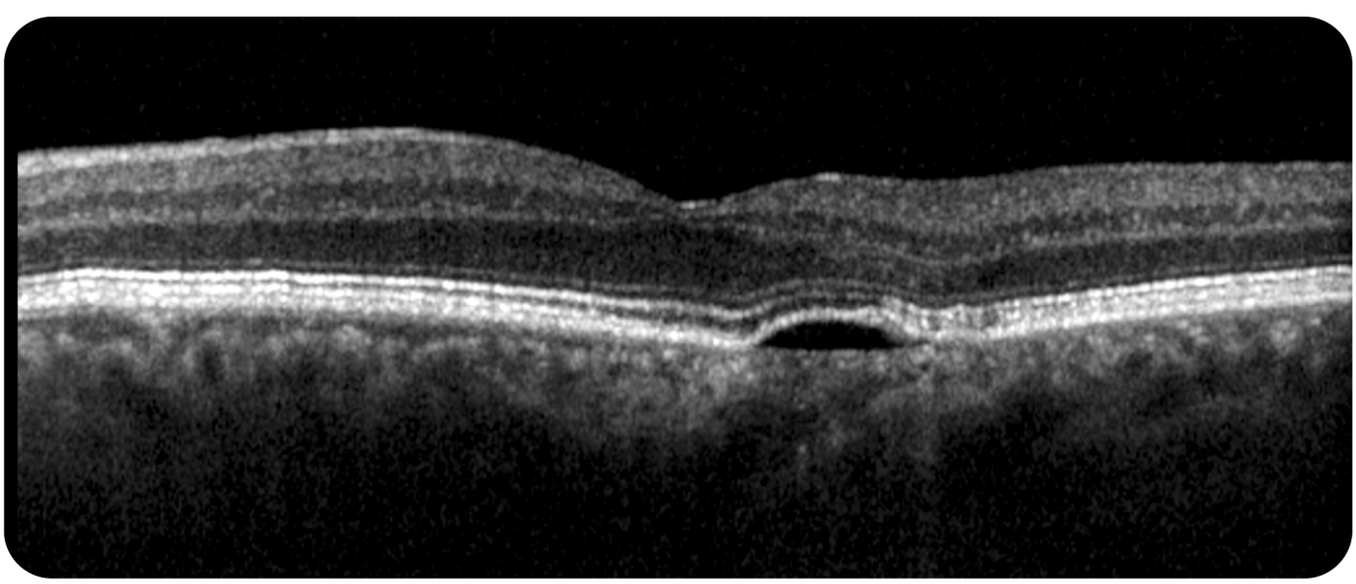
Age 68



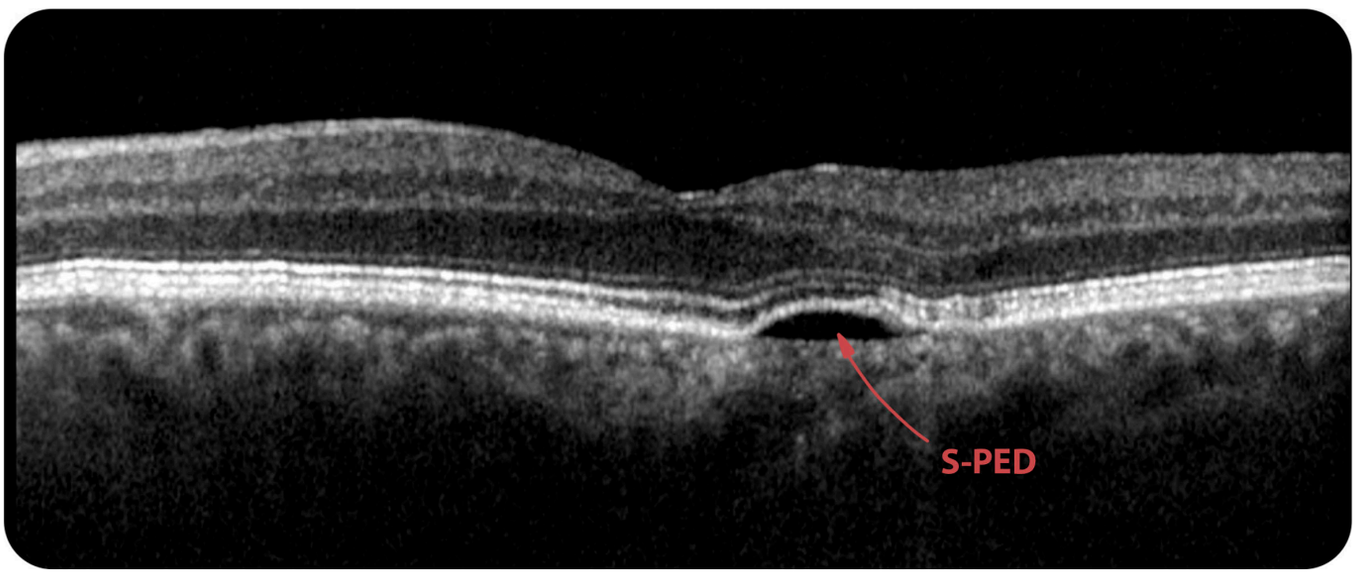
IR Image:
Central hyporeflective area indicating fluid accumulation with overlying speckled hyperreflective spots.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 84



Findings

Area	Alteration	Description
Subretinal	RPE	Elevated
	PED	Serous PED

Interpretation

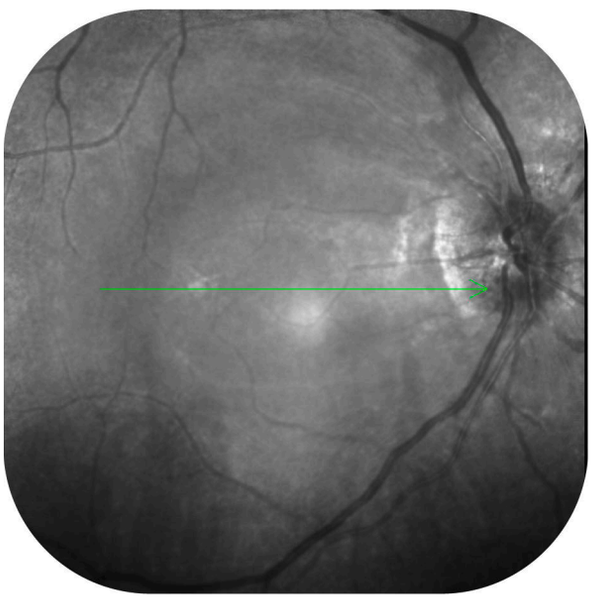
The most striking feature of this scan is the fluid accumulation that results in a serous PED. An EDI-scan would allow complete visualization of the choroid, possibly revealing a pachychoroid and **CSC** as the underlying cause for the S-PED. There are no other obvious alterations, neither in this scan or the IR image.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **S-PED**: Serous PED – **EDI:** Enhanced Depth Imaging – **CSC:** Central Serous Chorioretinopathy

Case 85

Case 85

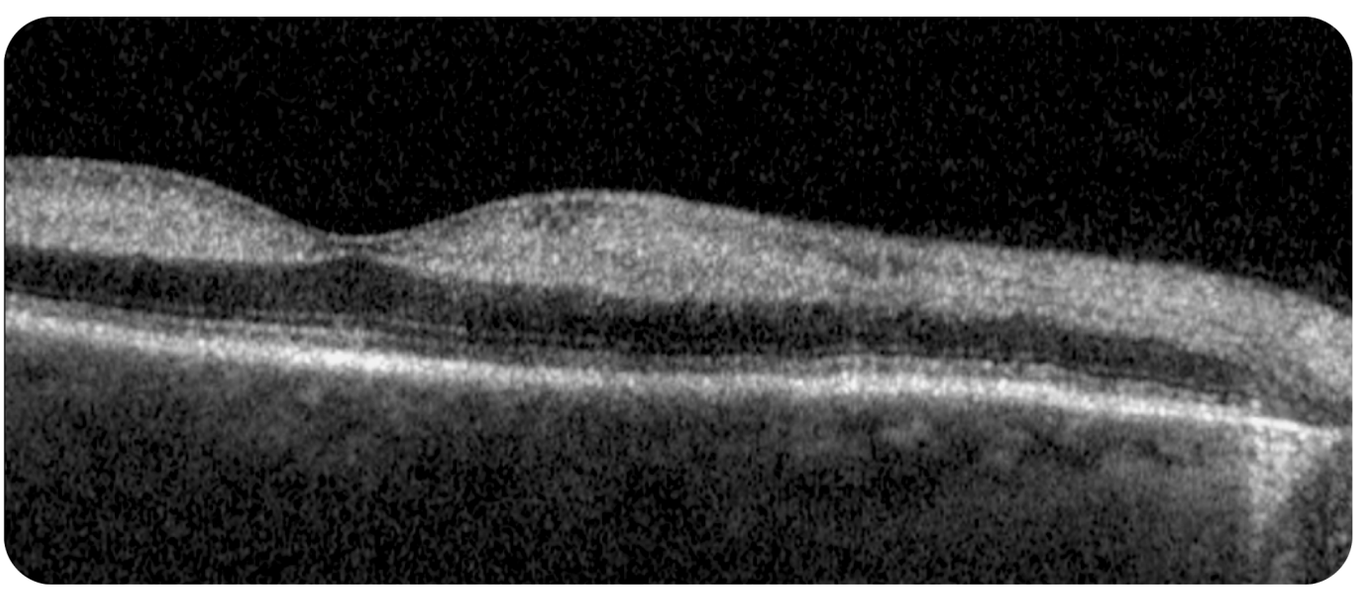
Age 68



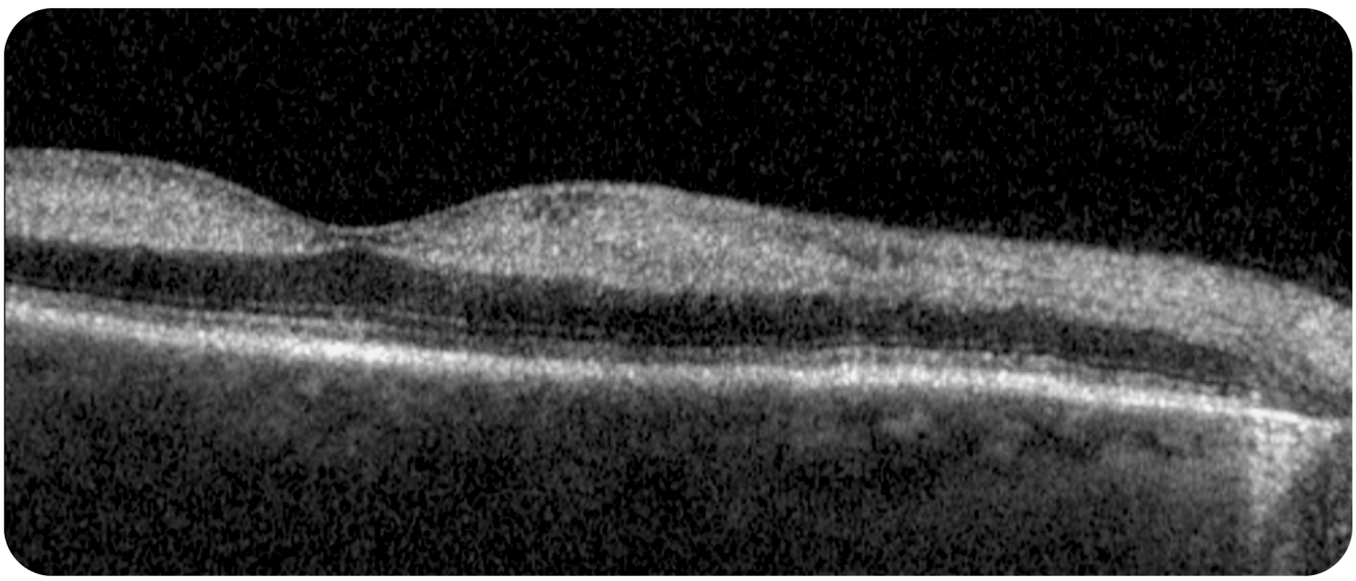
IR Image:
Blurred looking fundus with fading retinal vessels.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 85



Findings

Area	Structure	Description
Intraretinal	IRL	Hyperreflective appearance

Interpretation

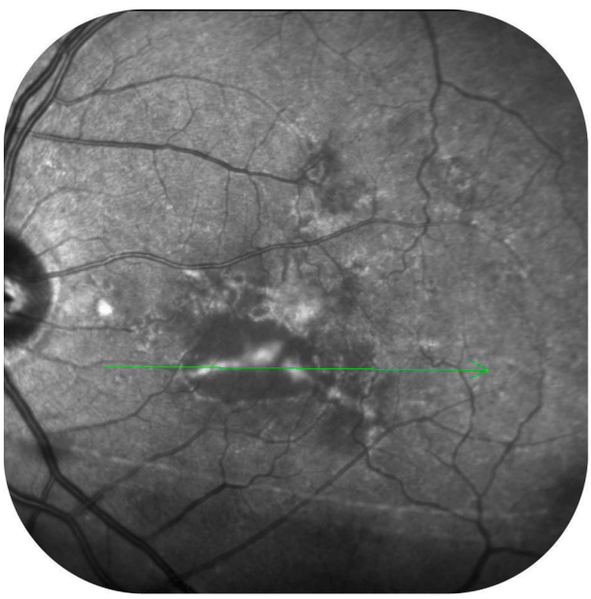
This patient presents with diffusely swollen and hyperreflective inner retinal layers – a picture consistent with retinal ischemia. (Likely due to a **central retinal artery occlusion**)

IRL: Inner Retinal Layers

Case 86

Case 86

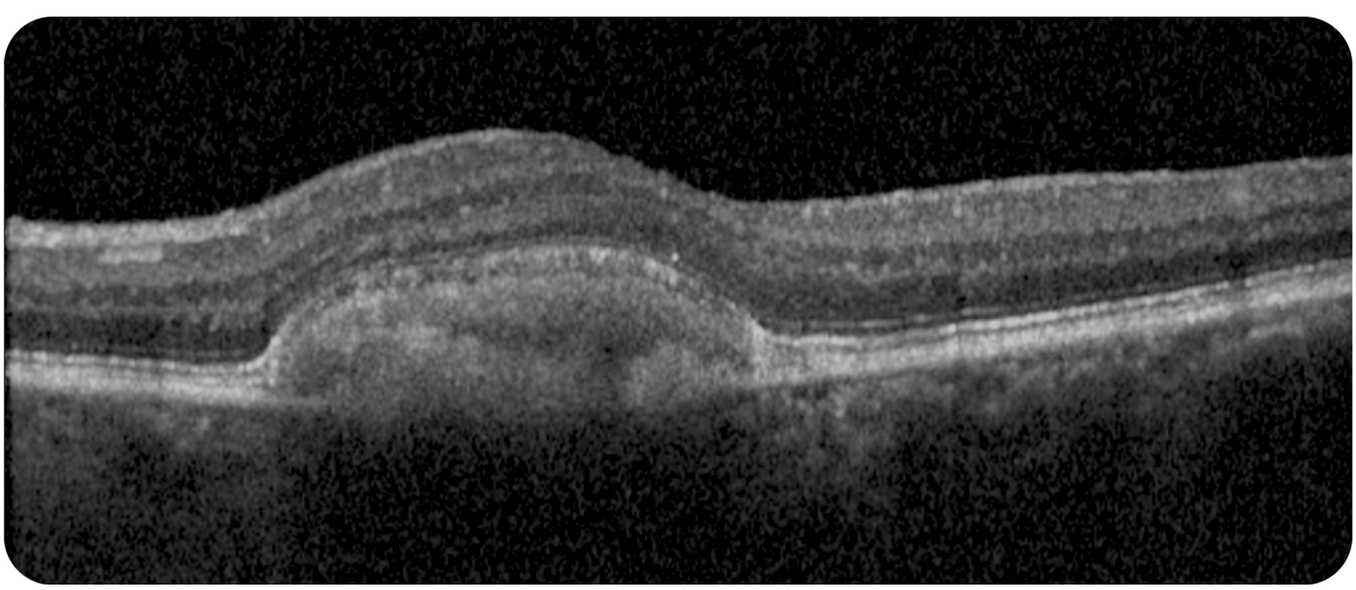
Age 78



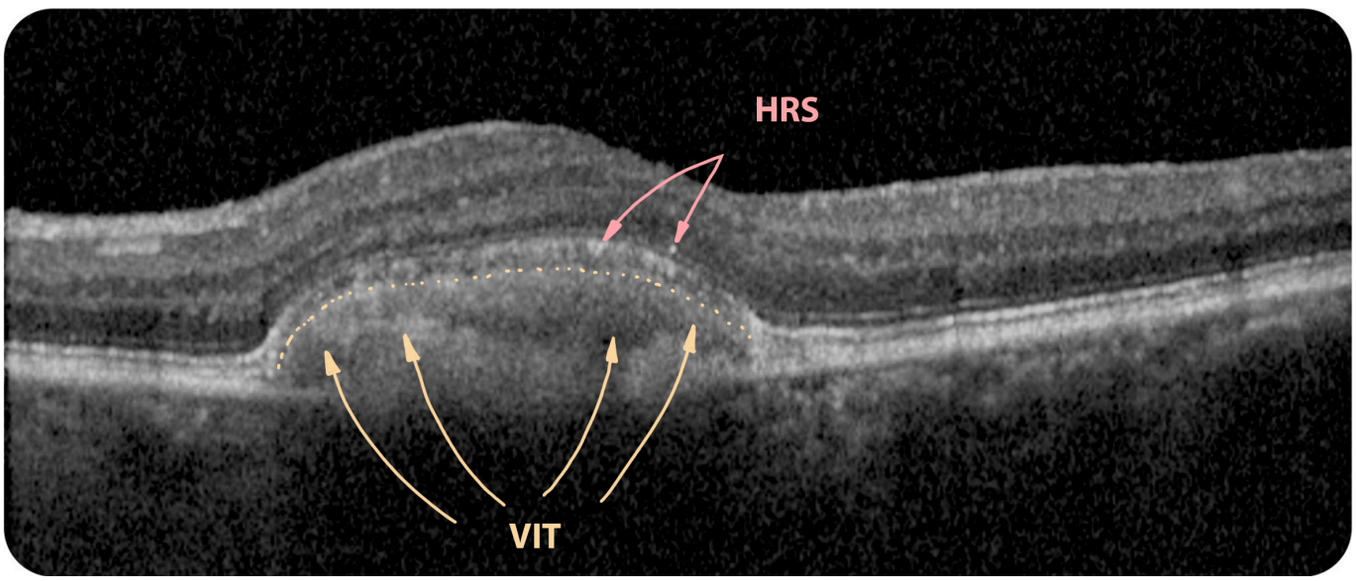
IR Image:
There is a well demarcated hyporeflective area with a hyperreflective band on top of it. Additionally, hypo- and hyperreflective areas are spread across the fundus.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 86



Findings

Area	Alteration	Description
Subretinal	RPE	Fading
	Vitelliform	Subretinal Vitelliform material
Intraretinal	HRS	Outer retina

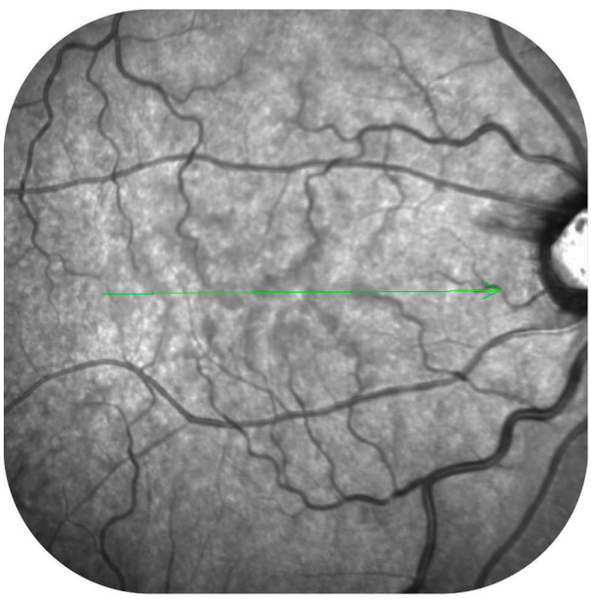
Interpretation

This patient has an accumulation of heterogeneous, medium to hyperreflective material in the subretinal area. The PR layer is well-demarcated, making an infiltrating process, like a MNV, rather unlikely – it is a picture consistent with a **vitelliform macular dystrophy**. However, for a definite diagnosis, further diagnostics such as color fundus photography, autofluorescence, OCT-A, or FA must be obtained. The PRs show first reactions to the prolonged detachment (HRS, irregular appearance)

RPE: Retinal Pigment Epithelium – **HRS**: Hyperreflective Spots – **PR**: Photoreceptor – **MNV**: Macular Neovascularization – **OCT-A:** Optical Coherence Tomography Angiography – **FA**: Fluorescence Angiography

Case 87

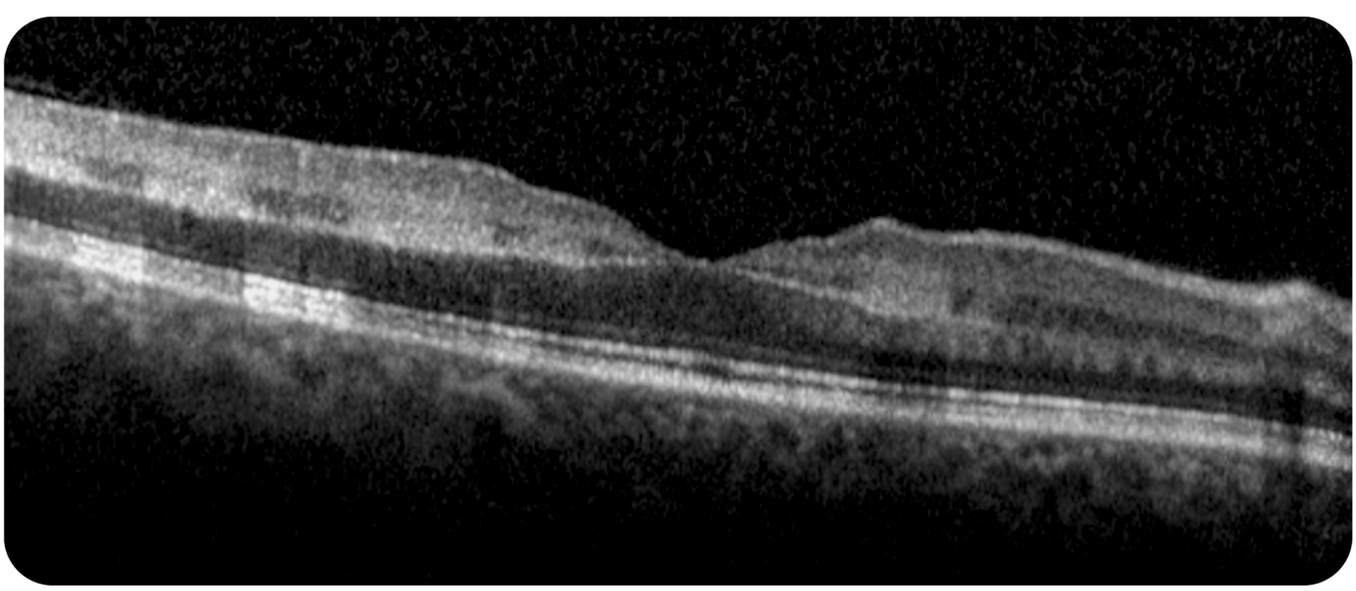
Age 68



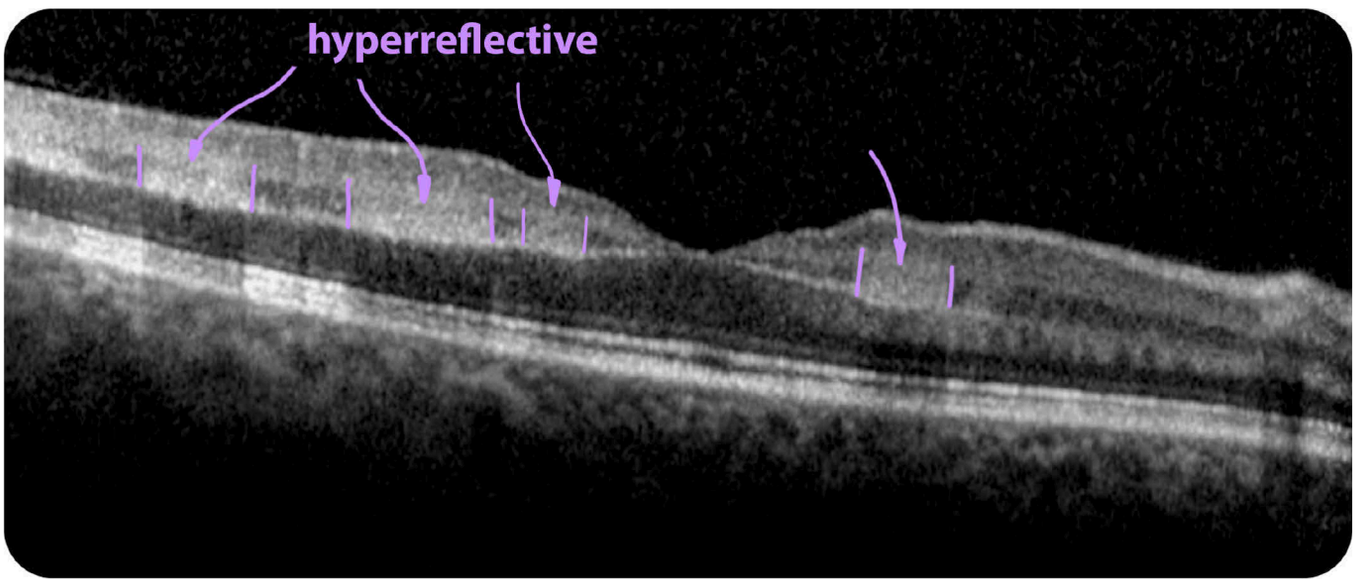
IR Image:
This patient presents with tortuous vessels and there are band-like hyporeflective areas spread over the entire macula.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 87



Findings

Area	Structure	Description
Intraretinal	IRL	Hyperreflectivity

Interpretation

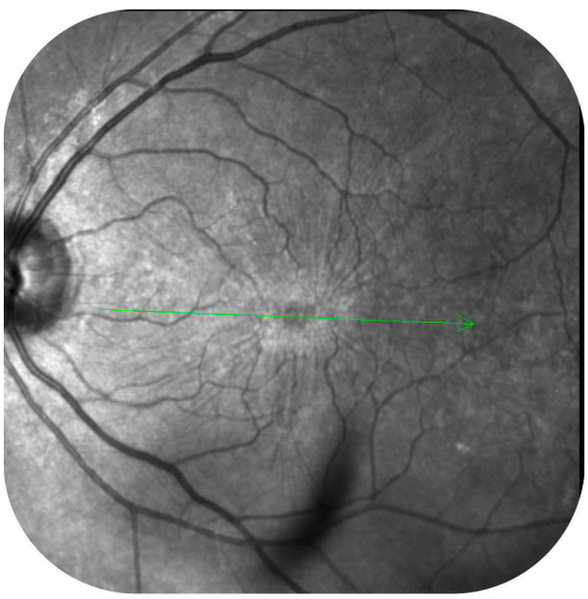
There are multiple hyperreflective sections within the inner retinal layers, likely representing areas of ischemia – a picture consistent with **paracentral acute middle maculopathy** (PAMM).

IRL: Inner Retinal Layers – **PAMM**: Paracentral acute middle maculopathy

Case 88

Case 88

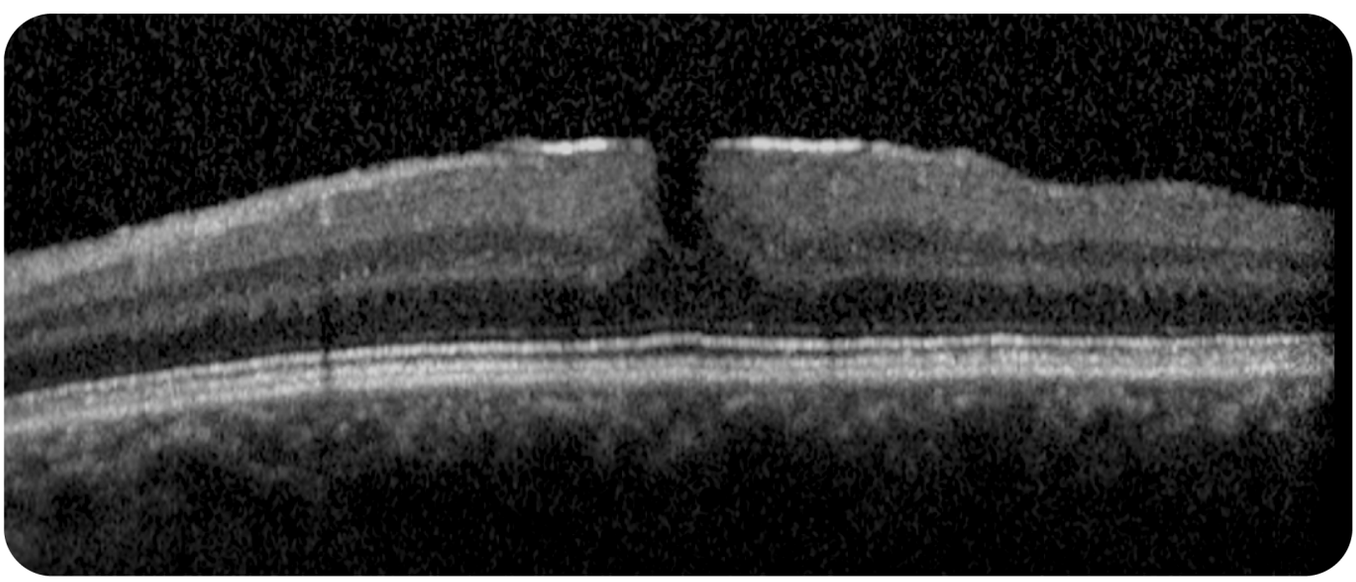
Age 68



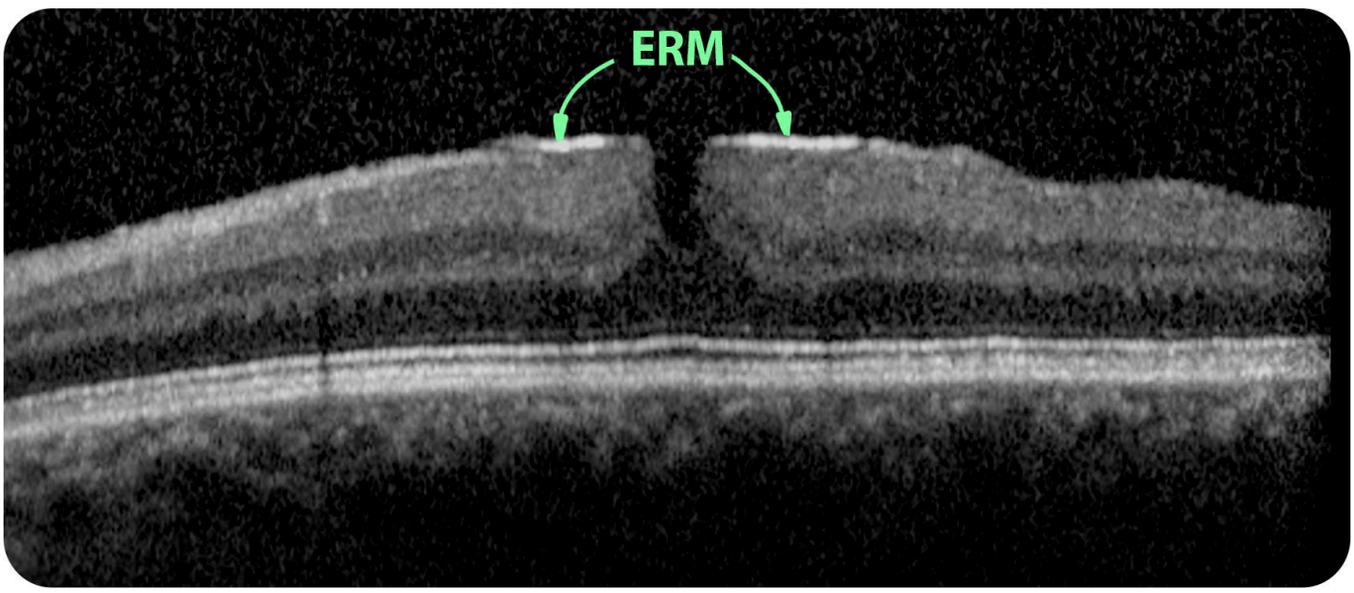
IR Image:
This patient has a volcano-like appearance of the macula with a circular striated pattern and a hyporeflective center. The hyporeflective veil in the inferior part of the image may represent a vitreous opacity.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 88



Findings

Area	Alteration	Description
Epiretinal	ERM	Epiretinal membrane

Interpretation

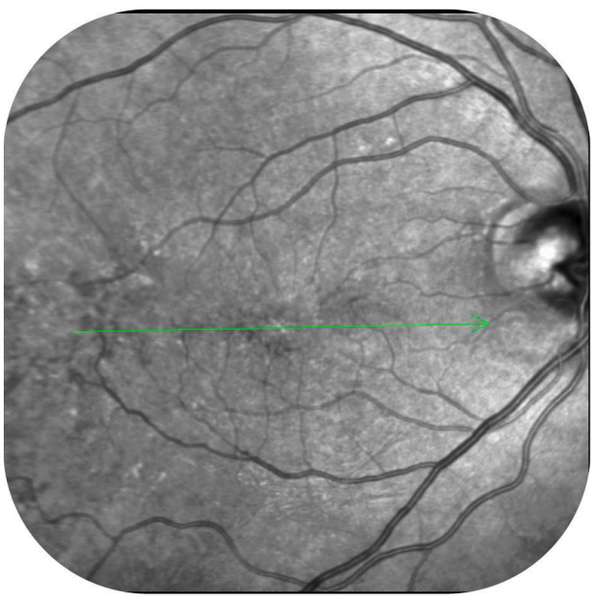
In this scan, we are looking at a patient with a thick ERM causing a deformation of the foveal contour, leading to the formation of a **pseudo macular hole**, which should not be mistaken as a lamellar macular hole.

ERM: Epiretinal Membrane

Case 89

Case 89

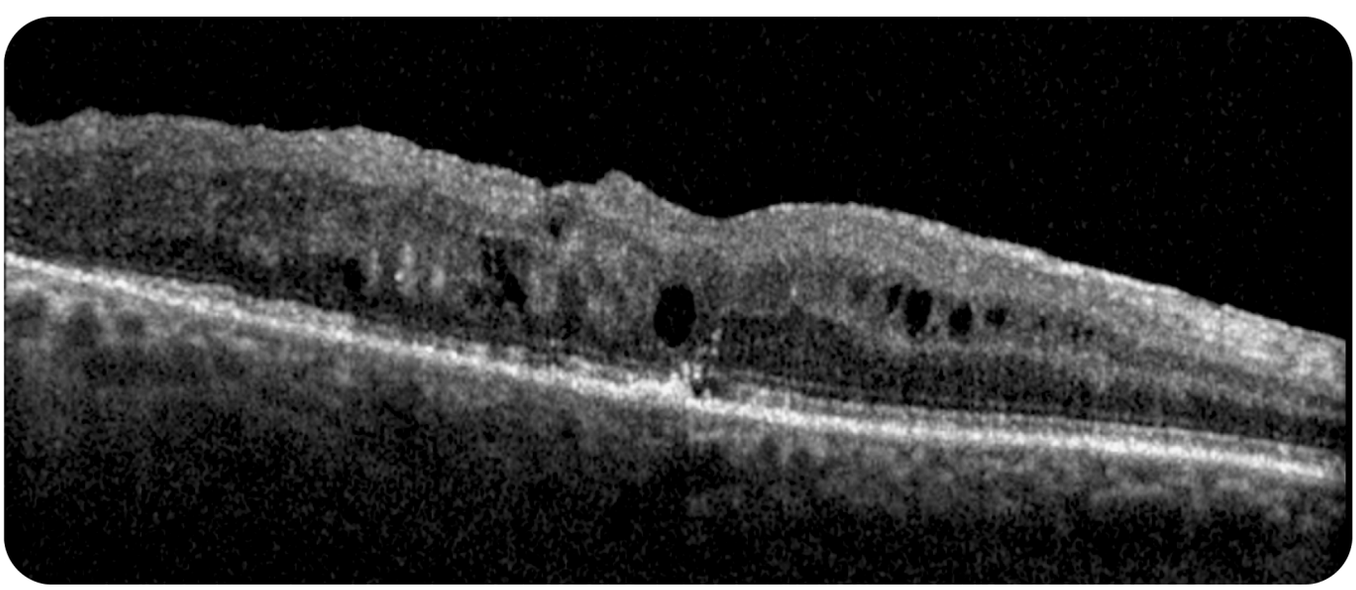
Age 68



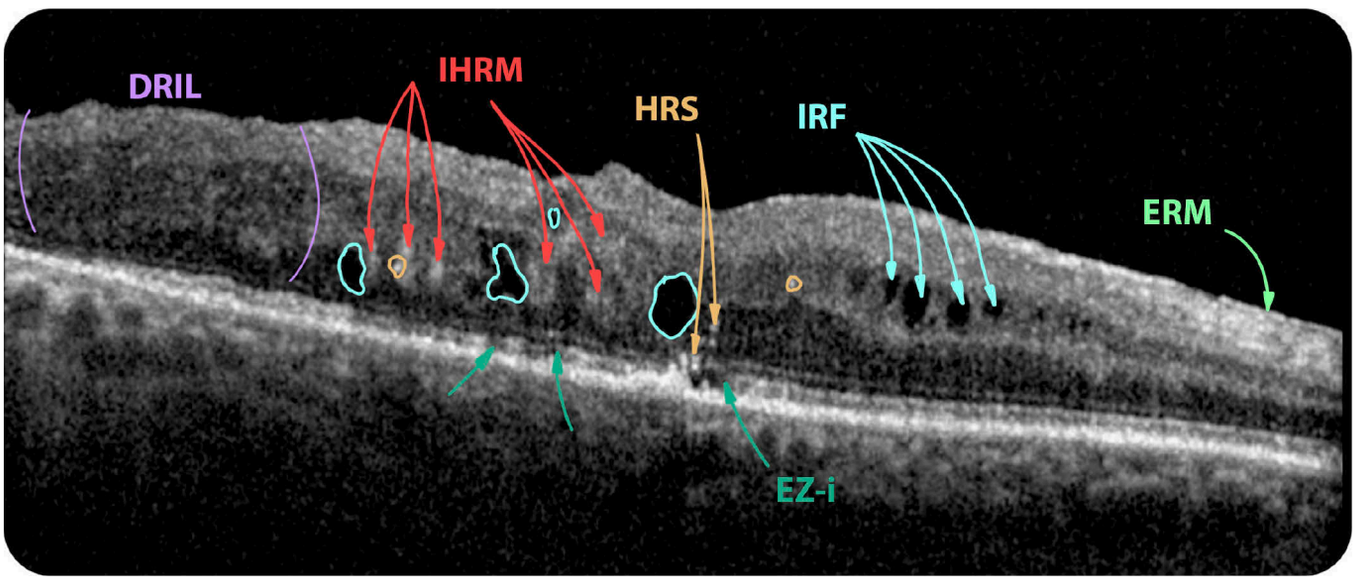
IR Image:
Irregular appearance of the fovea as well as the temporal fundus.

Scan Quality:
Good with no artifacts

Location:
Parafovea



Case 89



Findings

Area	Alteration	Description
Subretinal	RPE	Irregular, clumped
	PR	EZ interrupted
Intraretinal	IHRM	Medium reflective (fuzzy) with IRF
	IRF	Widespread
	HRS	Mainly outer retina
	DRIL	Disorganization
Epiretinal	ERM	Thin

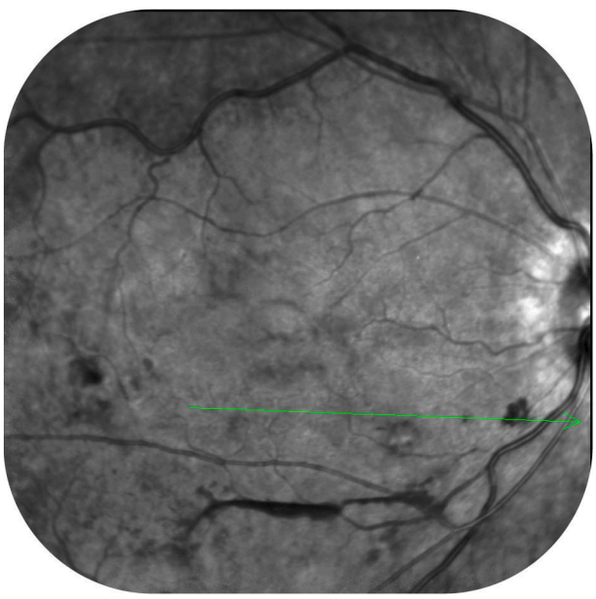
Interpretation

The most striking feature of this eye is the IHRM with associated IRF that is likely representing a **type 3 MNV**. In addition, there is an area of RPE clumping and associated pigment migration (HRS). While the EZ is clearly interrupted at the area of pigment clumping, the EZ irregularities on the left side might only be due to shadowing from the overlying alterations. The HRS around the IHRM could represent extravasated lipids. On the left side of the scan, the retinal layers are significantly disorganized.

RPE: Retinal Pigment Epithelium – **PR**: Photoreceptor – **EZ**: Ellipsoid Zone – **EZ-i:** Ellipsoid Zone Interruption – **IHRM**: Intraretinal Hyperreflective Material – **IRF**: Intraretinal Fluid – **HRS**: Hyperreflective Spots – **DRIL**: Disorganization of Retinal Inner Layers – **ERM**: Epiretinal Membrane – **MNV**: Macular Neovascularization

Case 90

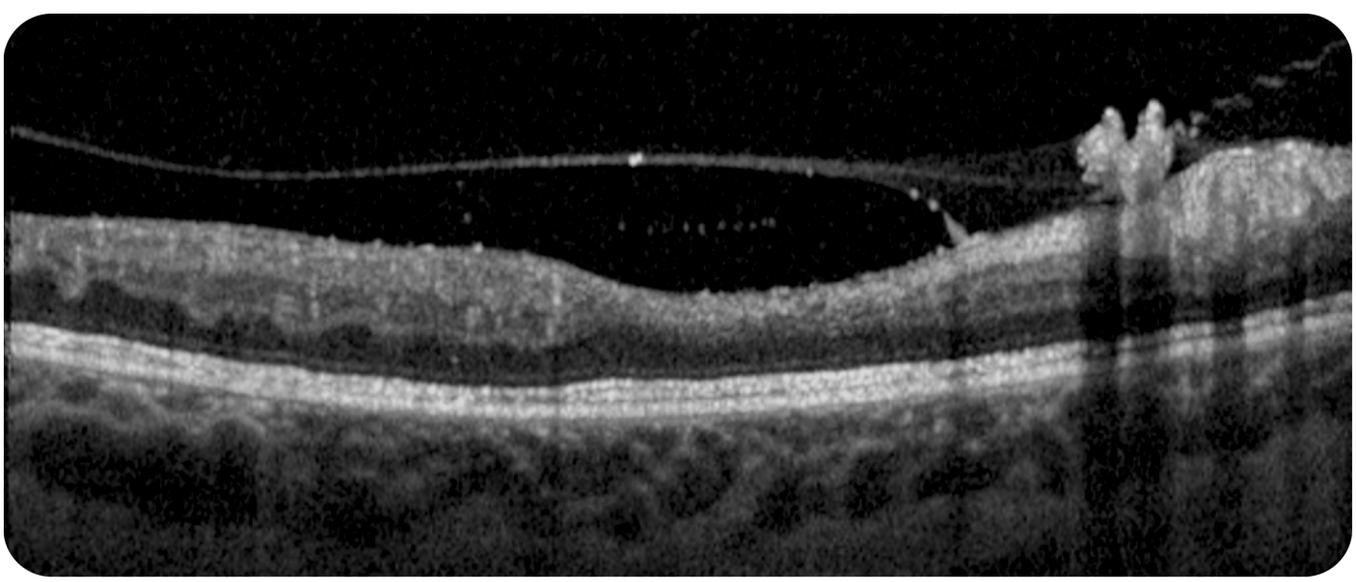
Age 68



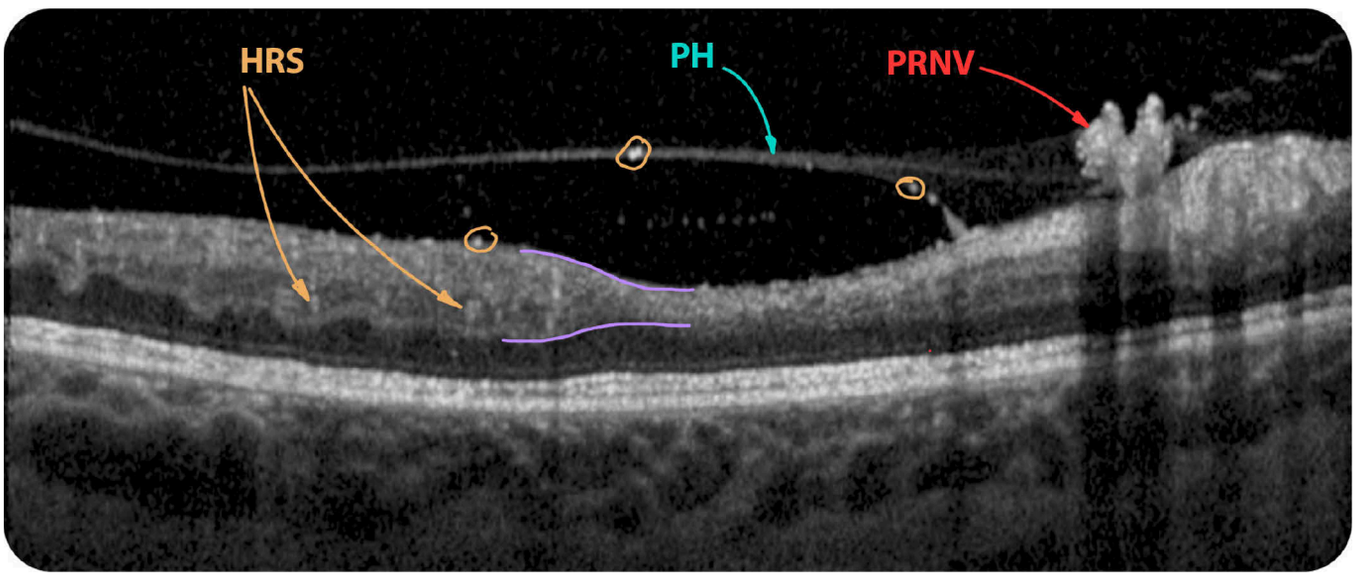
IR Image:
The macula appears irregular with alternating hypo- to medium reflective areas. A small blood pool seems to have formed along the inferior arcade and there is a dark grape-like formation next to the optic disk temporal to the inferior vein.

Scan Quality:
Good with no artifacts

Location:
Perifovea



Case 90



Findings

Area	Alteration	Description
Intraretinal	HRS	Around the inner layers
	IRL	Thinning
Preretinal	PRNV	Neovascularization
	PH	Posterior hyaloid
	VO	Blood cells

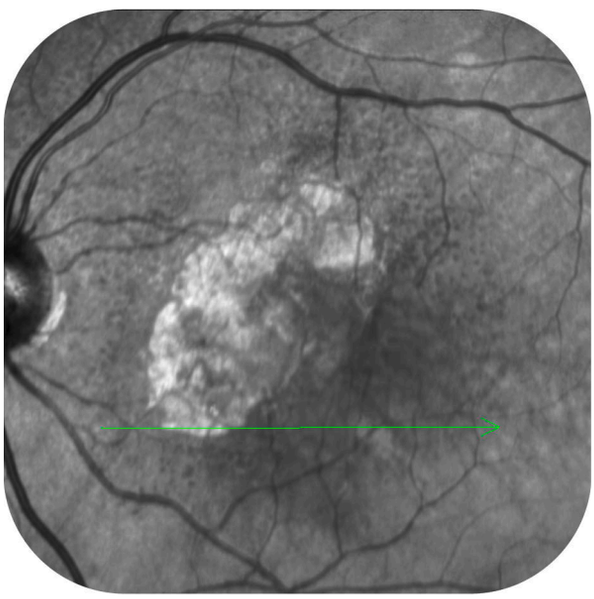
Interpretation

In this patient, the sectorial thinning of the inner retinal layers, points to a **past ischemic event** with subsequent retinal atrophy. In addition, there is some hyperreflective material in the epi/preretinal area, which most likely represents a **preretinal neovascularization**. Originating from the PRNV, membranous strands connect with the vitreous leading to the suspect diagnosis of **a proliferative vitreoretinopathy** (PVR). While the HRS in the vitreous likely represent blood, the entity of the intraretinal HRS is ambiguous and could represent dilated vessels of the capillary plexus or extravasated material. This patient is very likely suffering from a **retinal vascular disease with secondary neovascularization**.

HRS: Hyperreflective Spots – **IRL**: Inner Retinal Layers – **PRNV**: Preretinal Neovascularization – **PH**: Posterior Hyaloid – **VO**: Vitreous Opacity – **PVR**: Proliferative Vitreoretinopathy

Case 91

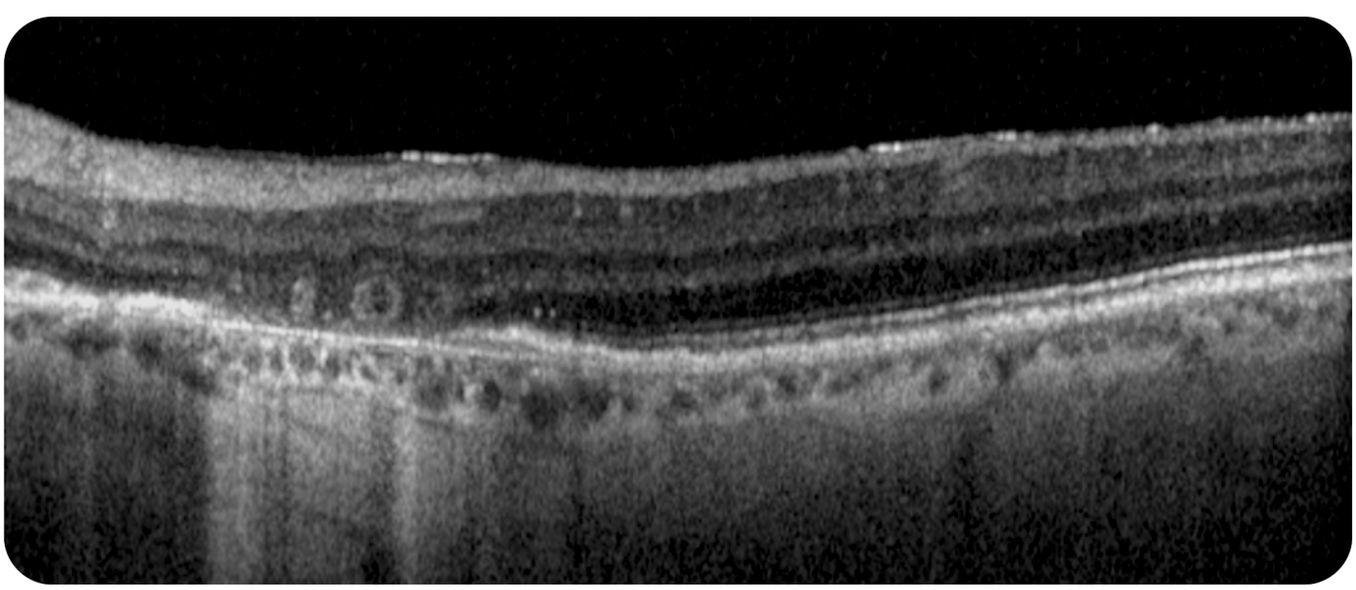
Age 68



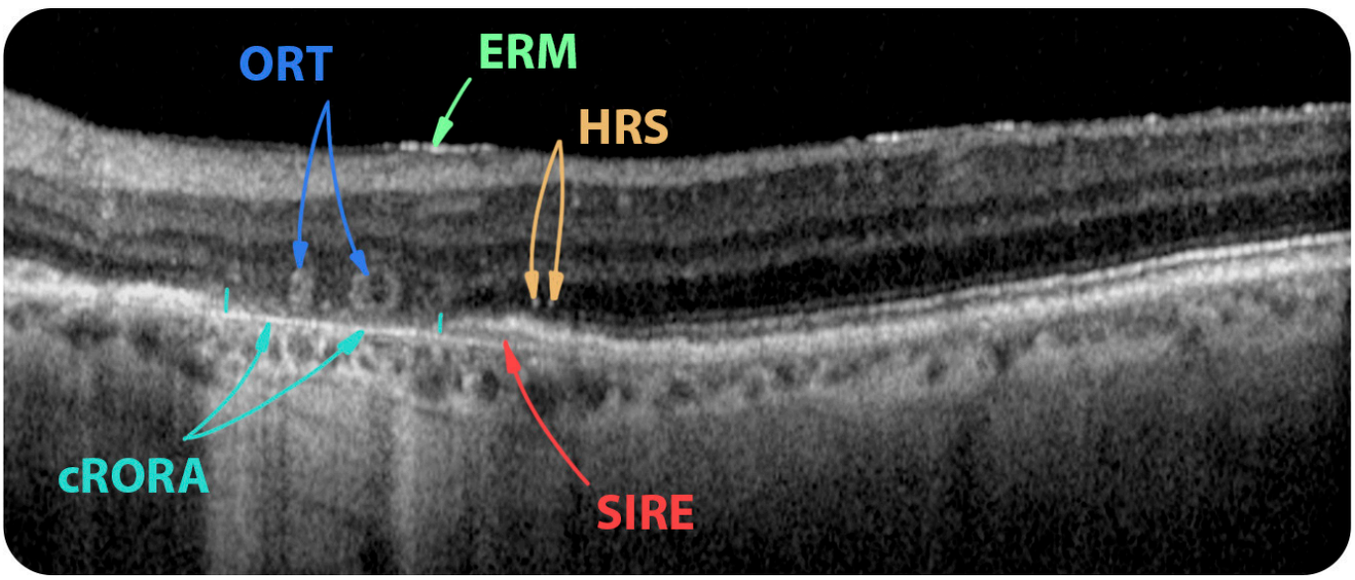
IR Image:
Large hyperreflective area of GA with visualization of the choroidal vessels that is involving most of the macula.

Scan Quality:
Good with no artifacts

Location:
Perifovea



Case 91



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated, interrupted
	SIRE	With DLS
	Atrophy	cRORA
Subretinal	PR	ORT
Intraretinal	HRS	Associated to RPE alteration/PR atrophy
Preretinal	ERM	Epiretinal membrane

Interpretation

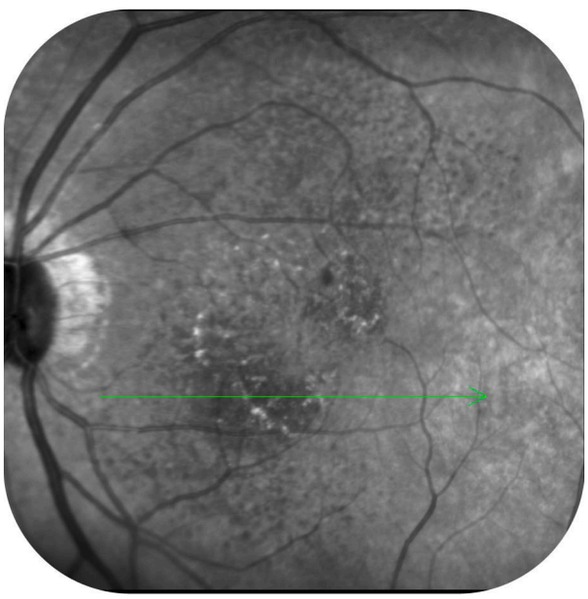
The most striking feature of this scan is the area of complete RPE atrophy (cRORA) with an additional rearrangement of PR, forming ORT (indicating chronicity and stability of disease). There is a SIRE with a DLS, however, without signs of exudation. Additionally, a thin ERM is present.

RPE: Retinal Pigment Epithelium – **SIRE**: Shallow Irregular RPE elevation – **DLS**: Double-layer Sign – **cRORA**: Complete RPE and Outer Retinal Atrophy – **PR**: Photoreceptor – **ORT**: Outer Retinal Tubulation – **HRS**: Hyperreflective Spots – **ERM**: Epiretinal Membrane – **GA:** Geographic Atrophy

Case 92

Case 92

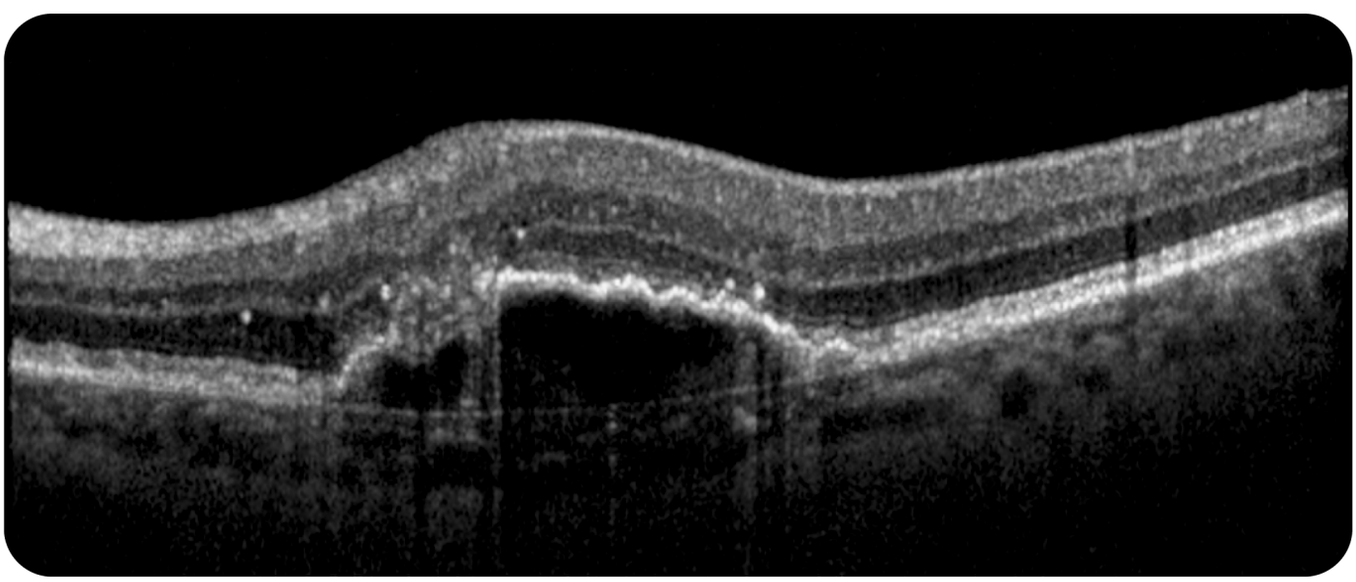
Age 78



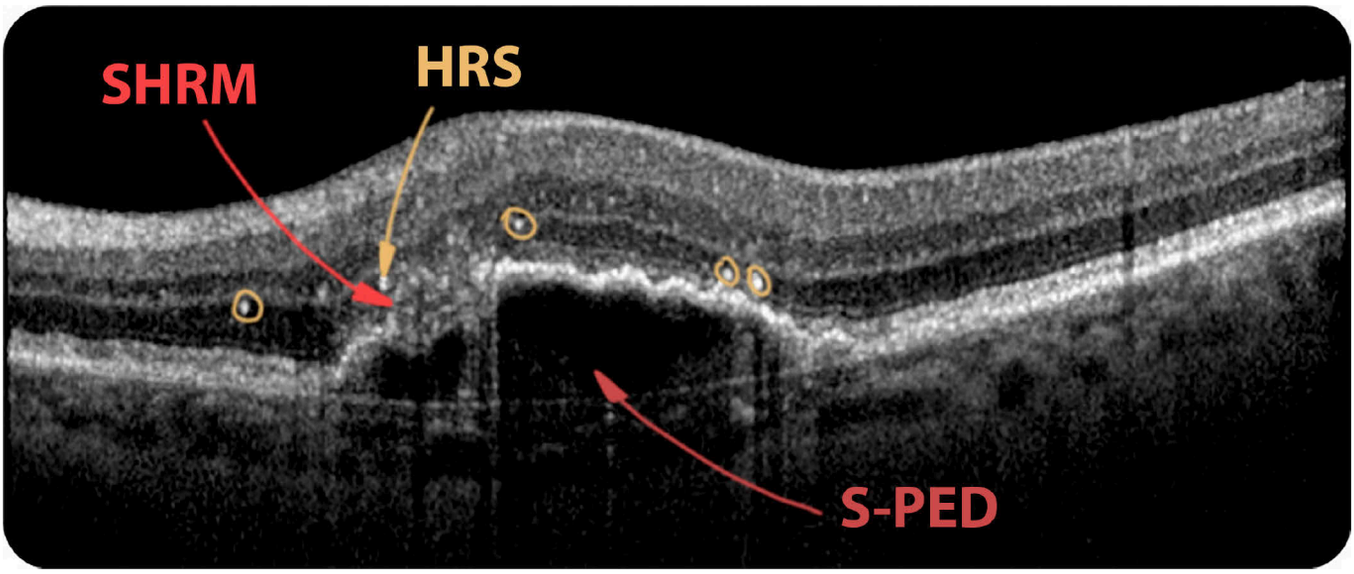
IR Image:
There are two hyporeflective areas with associated hyperreflective spots in the para-/perifoveal area. The reticular pseudodrusen cover large areas of the peripheral macula, sparing the fovea.

Scan Quality:
Good with no artifacts

Location:
Perifovea



Case 92



Findings

Area	Alteration	Description
Sub-RPE	RPE	Elevated
	PED	Serous-PED
Subretinal	SHRM	Medium reflective, fuzzy
Intraretinal	HRS	Associated to RPE alteration and exudation

Interpretation

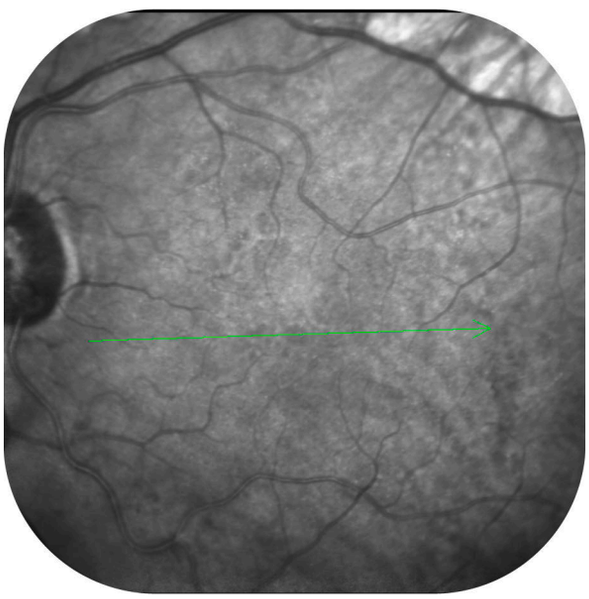
The most striking feature of this scan is the large serous PED with associated fuzzy looking SHRM. In conjunction with the findings in the IR image (reticular pseudodrusen), a **mixed type (1+2) MNV secondary to AMD** could be the basis for further diagnostics. The HRS could represent pigment migration and lipid exudates.

RPE: Retinal Pigment Epithelium – **PED:** Pigment Epithelial Detachment – **S-PED**: Serous PED – **SHRM**: Subretinal Hyperreflective Material – **HRS**: Hyperreflective Spots – **MNV:** Macular Neovascularization – **AMD:** Age-related Macular Degeneration

Case 93

Case 93

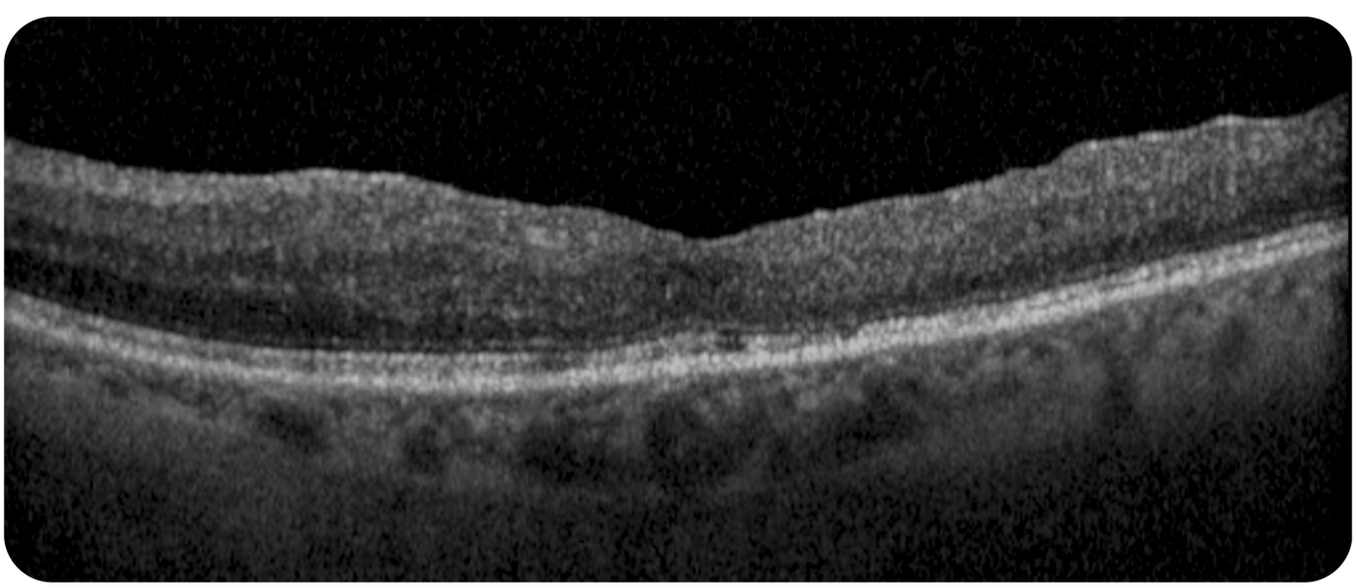
Age 68



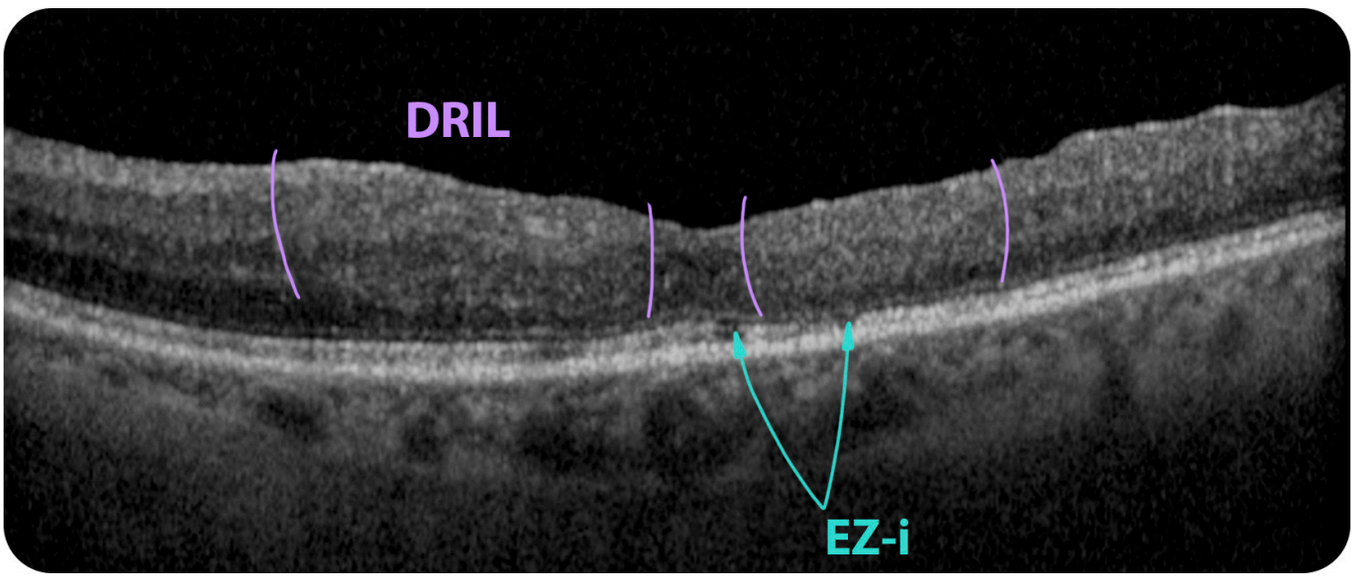
IR Image:
There are multiple subtle hyporeflective alterations spread across the macula.

Scan Quality:
Good with no artifacts

Location:
Parafovea/fovea



Case 93



Findings

Area	Alteration	Description
Subretinal	PR	EZ interrupted
Intraretinal	IRL	Disorganization

Interpretation

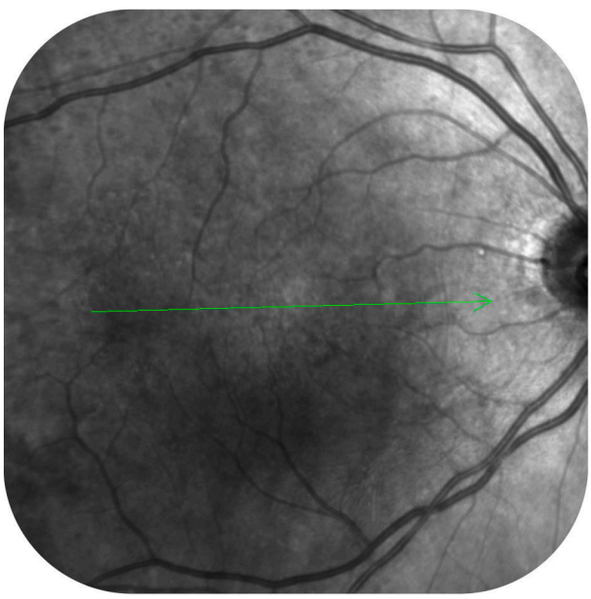
This patient has a severe **disorganization of the inner retinal layers** (DRIL) and a fragmented EZ, resulting in a comparatively poor visual prognosis. There are no clear indications of the underlying condition.

PR: Photoreceptor – **EZ:** Ellipsoid Zone – **EZ-i**: Ellipsoid Zone Interruption – **IRL**: Inner Retinal Layers

Case 94

Case 94

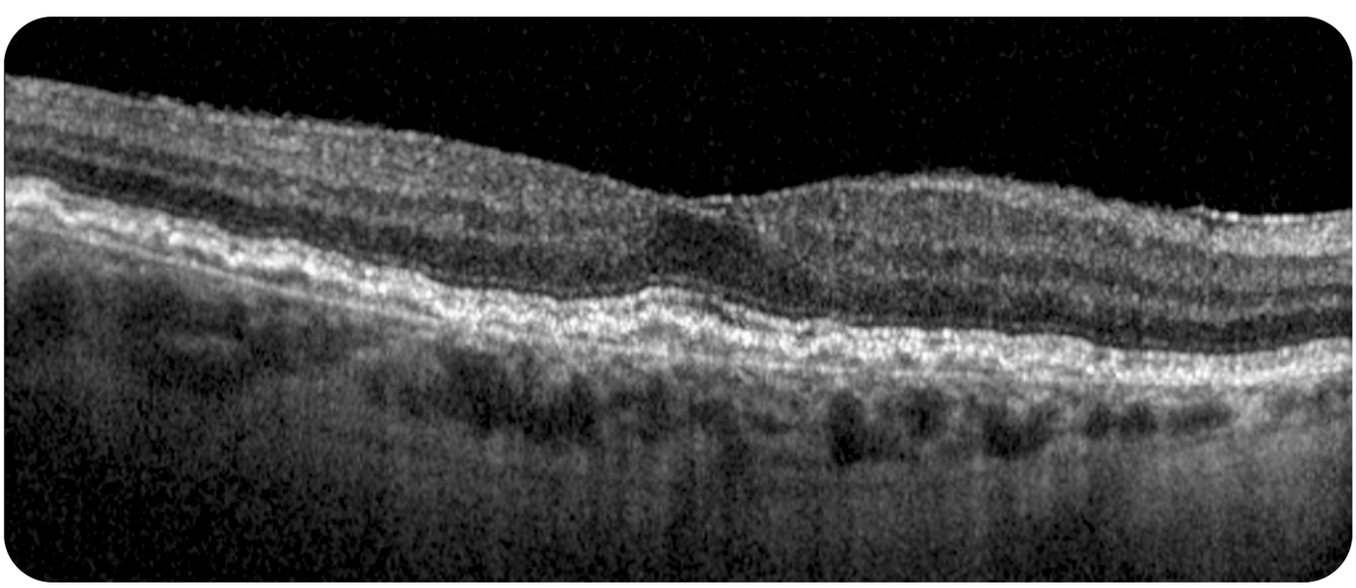
Age 68



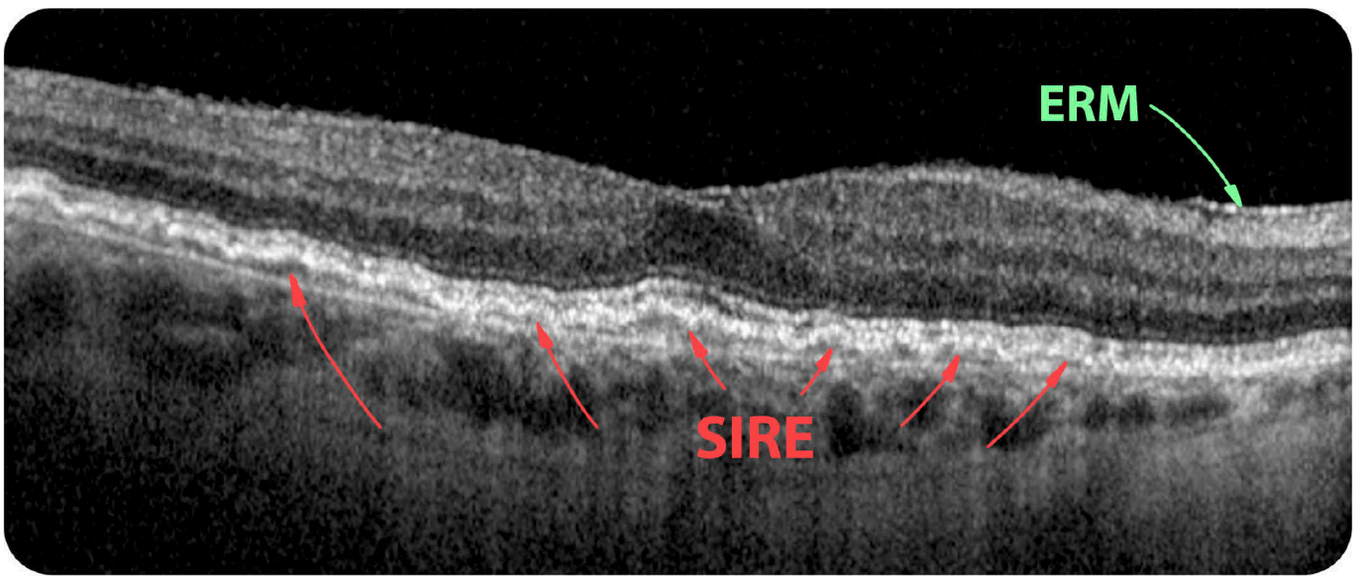
IR Image:
The inferior half of the macula has a hyporeflective appearance, furthermore, there are alterations spread across the entire fundus.

Scan Quality:
Good with no artifacts

Location:
Fovea



Case 94



Findings

Area	Alteration	Description
Sub-RPE	SIRE	With DLS
Epiretinal	ERM	Thin

Interpretation

This patient has a widespread SIRE with an evident DLS likely representing a **quiescent MNV**. This patient is at high risk for disease progression to an exudative form and should be monitored closely. Additionally, there is a thin ERM on the right side of the scan.

SIRE: Shallow Irregular RPE Elevation – **DLS**: Double-layer Sign – **MNV**: Macular Neovascularization – **ERM**: Epiretinal Membrane