Interpretation of OCT macula

Arun Lakshmanan
Consultant Ophthalmologist
Nottingham University Hospitals NHS Trust

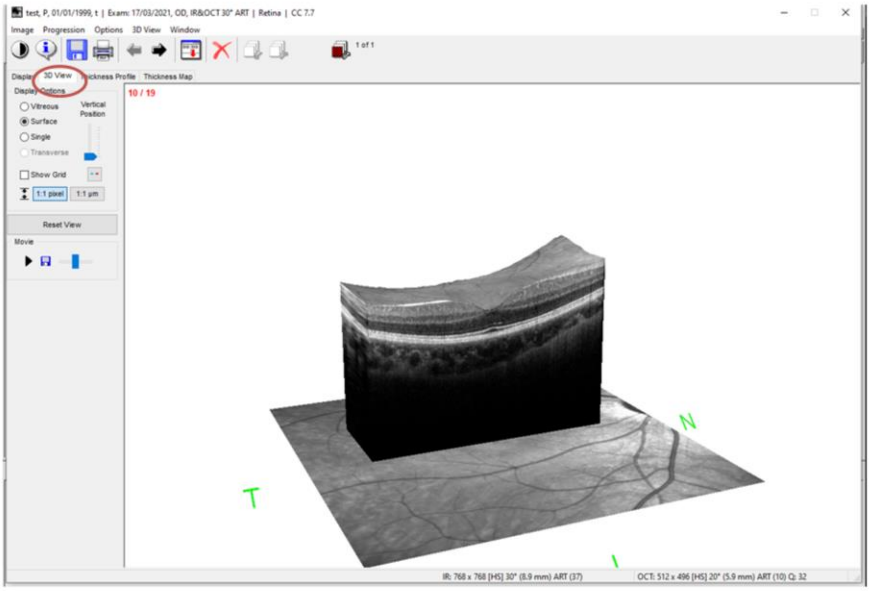
Optometry teaching
08.11.2022

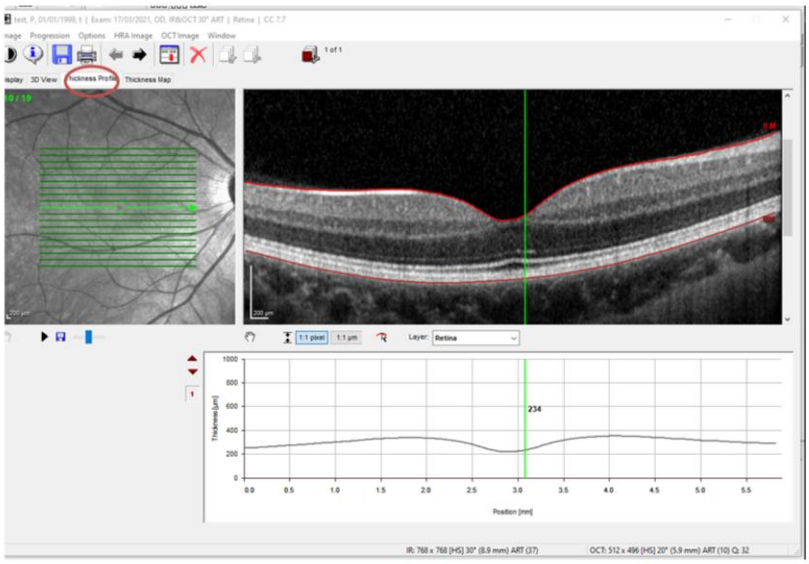
- No disclosures

- Know your machine
- Understand basic principles
- Interpretation of B-scan / layers
- Inner vs outer retina pathology
- Interpretation of thickness map

Image acquisition


Image
Progression
Options
HRA Image
OCT Image
Overlay
Window
1 of 1
Display
Thickness Profile
Thickness Map
10 / 19
Auto
1:1 pixel
1:1 µm


test, P, 01/01/1999, t | Exam: 17/03/2021, OD, IR&OCT 30° ART | Retina | CC 7.7
Image Progression Options 3D View Window
1 of 1
3D View
Thickness Profile
Thickness Map
Display Options
Vitreous
Surface
Single
Transverse
Vertical Position
Show Grid
1:1 pixel
1:1 µm
Reset View
Movie
10 / 19
T
N
I
IR: 768 x 768 [HS] 30° (8.9 mm) ART (37)
OCT: 512 x 496 [HS] 20° (5.9 mm) ART (10) Q: 32


Progression
Options
HRA Image
OCT Image
Window
3D View
Thickness Profile
Thickness Map
1 of 1
1:1 pixel
1:1 µm
Layer:
Retina
Thickness [µm]
Position [mm]
234
IR: 768 x 768 [HS] 30° (8.9 mm) ART (37)
OCT: 512 x 496 [HS] 20° (5.9 mm) ART (10) Q: 32

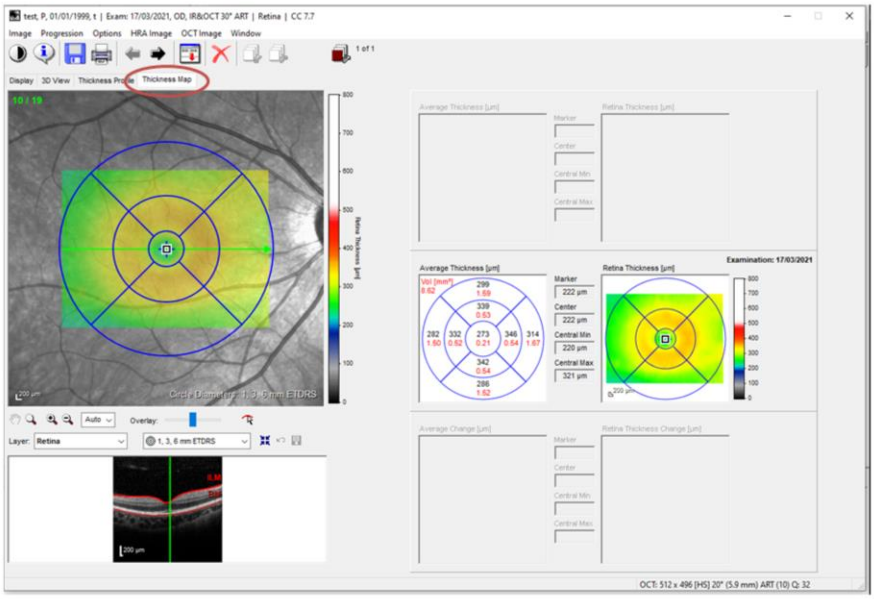
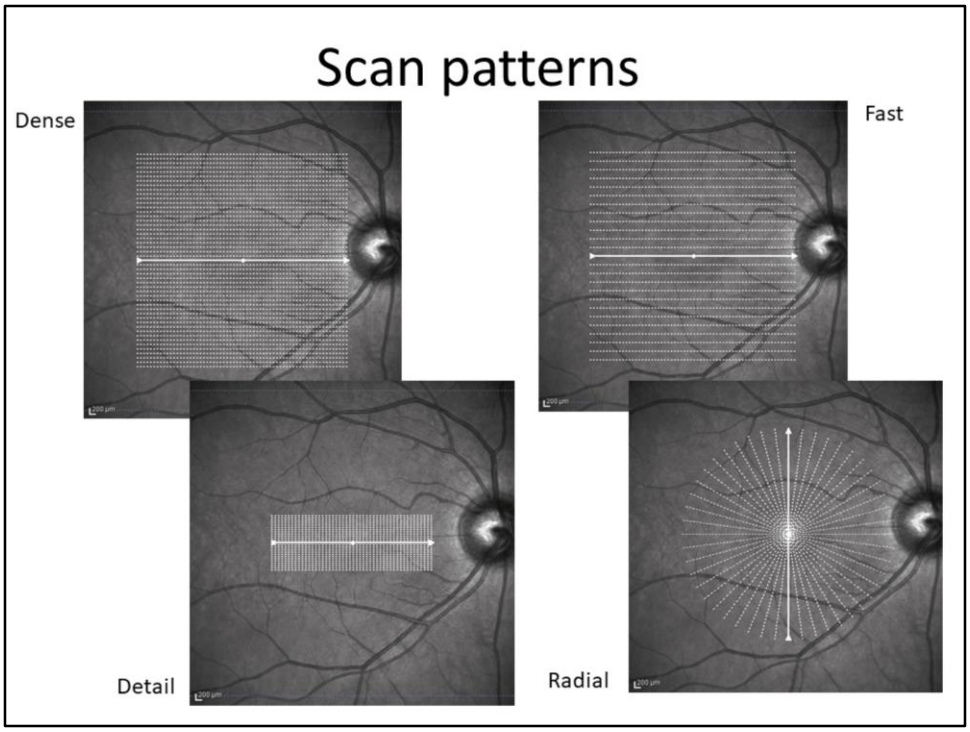
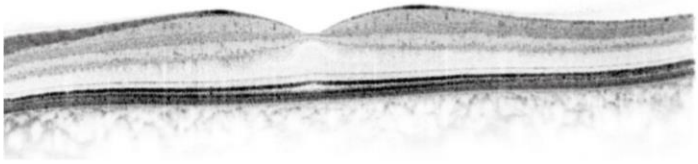


Image Progression Options HRA Image OCT Image Window
Display 3D View Thickness Profile Thickness Map
Average Thickness [µm]
Retina Thickness [µm]
Examination: 17/03/2021
Average Thickness [µm]
Retina Thickness [µm]
Marker
Center
Central Min
Central Max
Average Change [µm]
Retina Thickness Change [µm]
Layer: Retina
OCT: 512 x 496 [HS] 20° (5.9 mm) ART (10) Q: 32

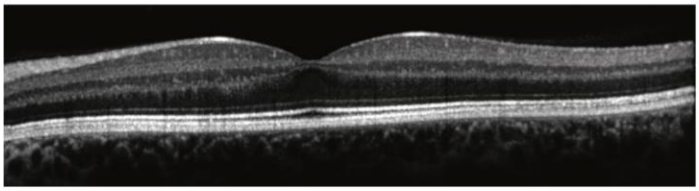


Two high-resolution central OCT images of the fovea should be documented for every eye with perifoveal abnormalities. These should have a horizontal and vertical orientation and should intersect the fovea. Furthermore, a volume scan should be adjusted in terms of size/density and placed over the area of interest as indicated on the fundus image. FAST scan 25 lines, 240 microns apart, ART 9

Colour Schemes

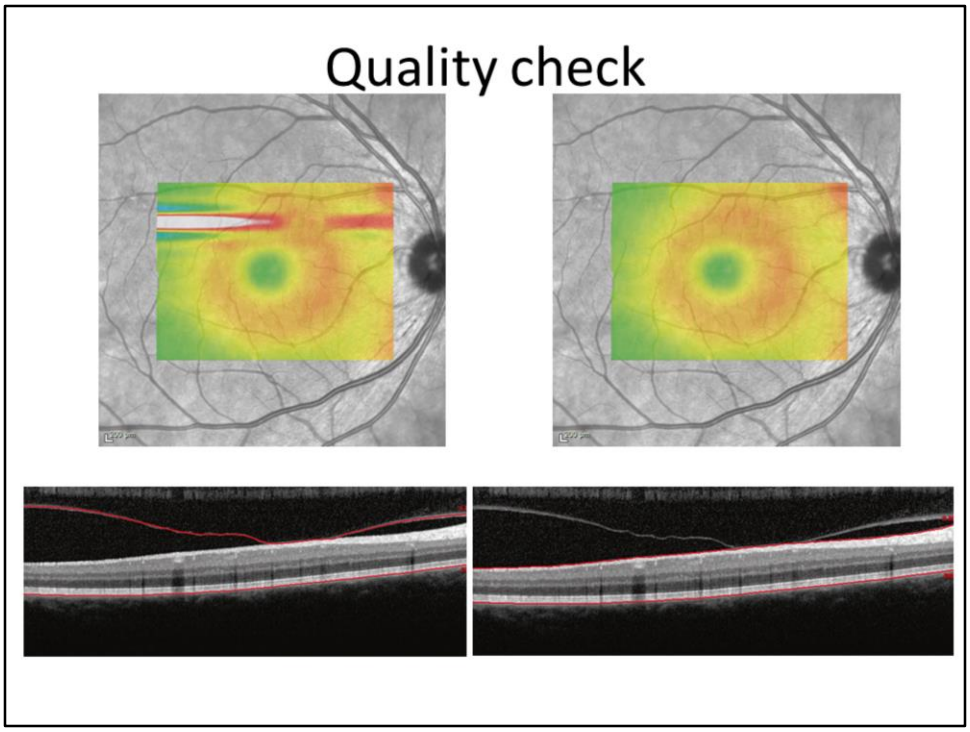


OCT image on a white background
("hyperreflective" = black, "hyporeflective" = white)

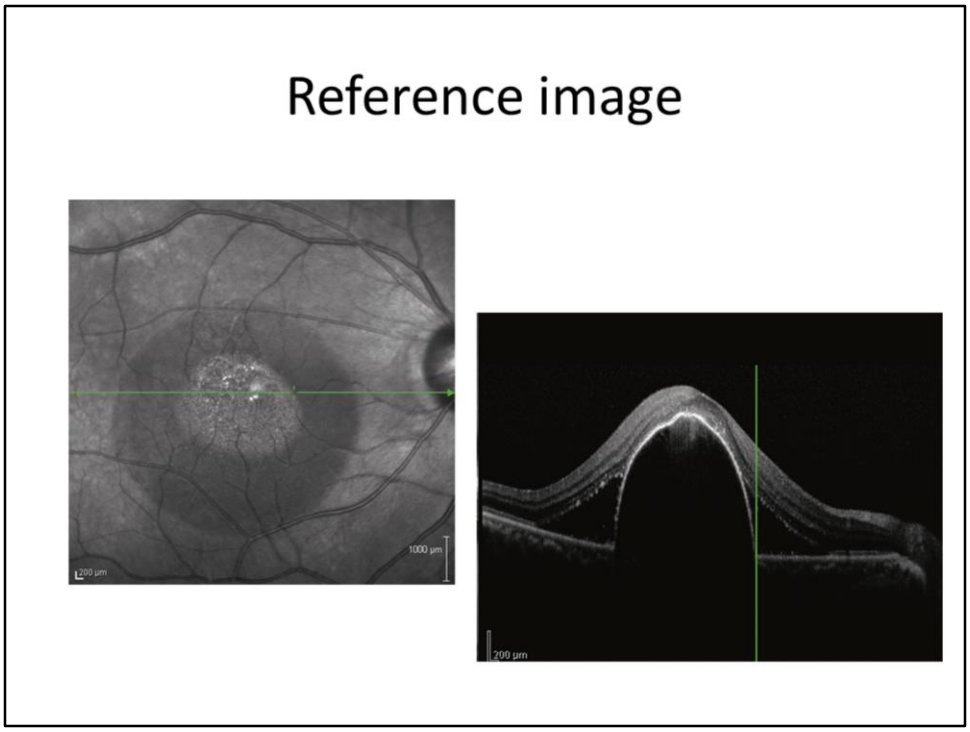


OCT image on a black background
("hyperreflective" = white, "hyporeflective" = black)

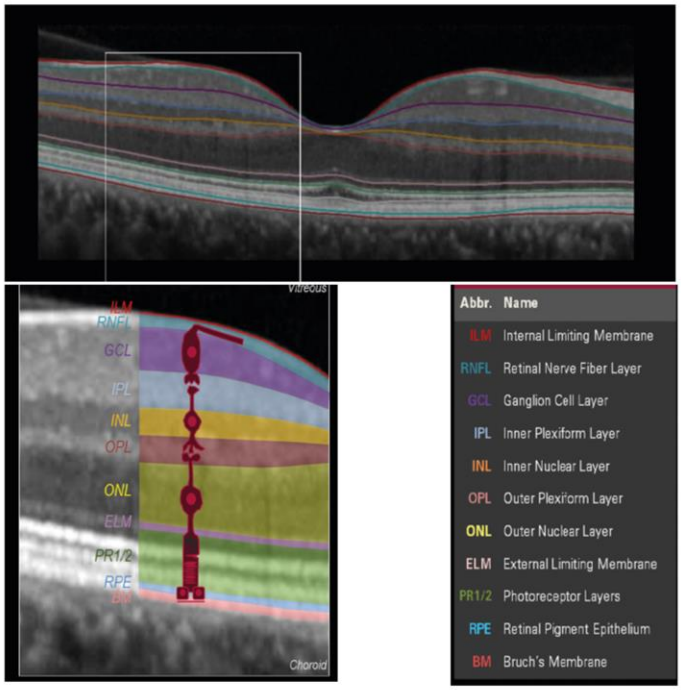
It is possible to view OCT images with different colour schemes. For clinical use, black-on-white and white-on-black are most common. Changing the colour scheme does not change the information included in the image. However, it is sometimes helpful to reverse the contrast to highlight areas of interest



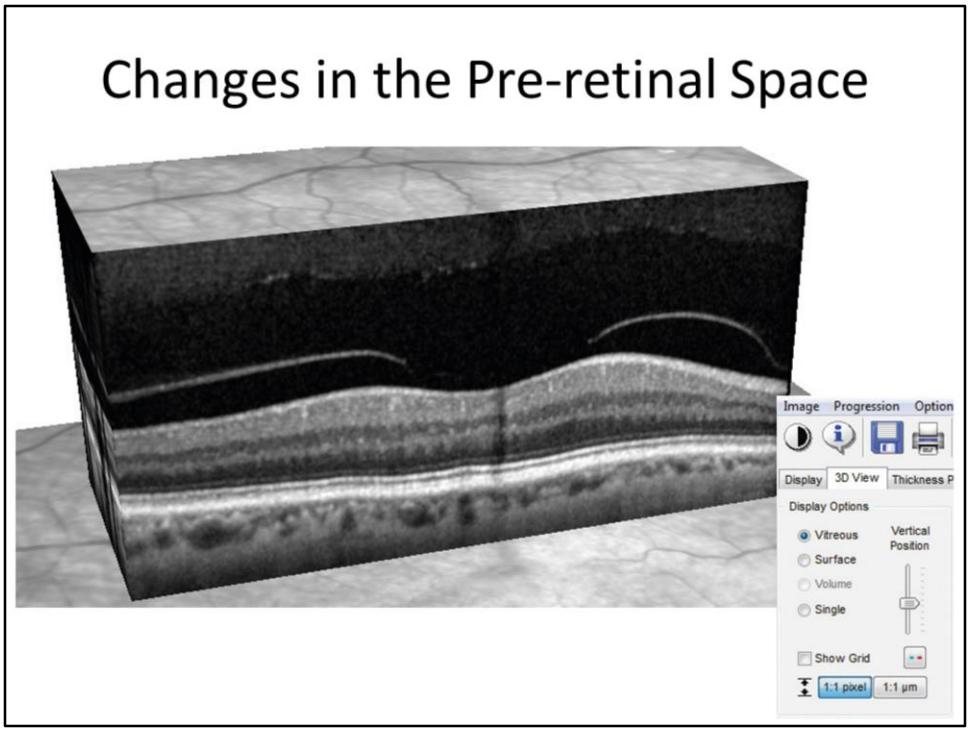
Segmentation error: Every single OCT image of the volume scan should be observed and analyzed. If the thickness map is of interest, the automatic segmentation of each OCT section image should be reviewed to ensure no errors were made



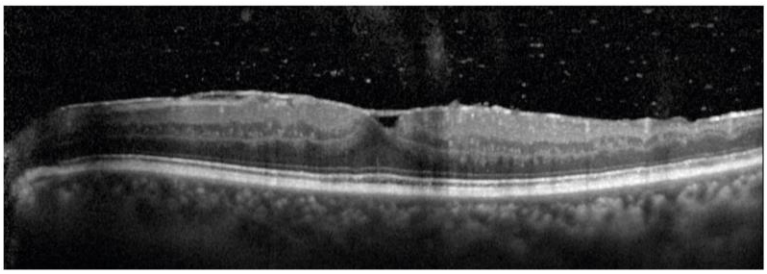
Correlating the changes visible on the IR image with the OCT image: Every OCT image is associated with a reference fundus image: By simultaneously displaying the fundus image and OCT image, it is possible to precisely correlate clinically abnormal areas to the corresponding finding on the OCT image



Abbr.	Name
ILM	Internal Limiting Membrane
RNFL	Retinal Nerve Fiber Layer
GCL	Ganglion Cell Layer
IPL	Inner Plexiform Layer
INL	Inner Nuclear Layer
OPL	Outer Plexiform Layer
ONL	Outer Nuclear Layer
ELM	External Limiting Membrane
PR1/2	Photoreceptor Layers
RPE	Retinal Pigment Epithelium
BM	Bruch's Membrane

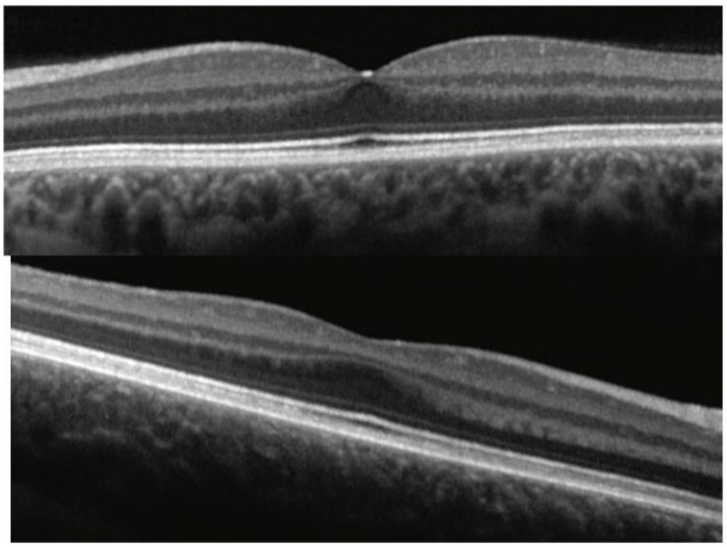


Shadows appearing on the OCT image that are not caused by a hemorrhage or an exudate may originate from the vitreous body. Vitreous opacities appear as reflective spots in the OCT image. The use of 3D imaging especially helps to identify a correlation between abnormalities in the vitreous body and the OCT image, e.g. in case of floaters (Fig. 12). In the “3D view” tab the vitreous option needs to be selected (Fig. 13).



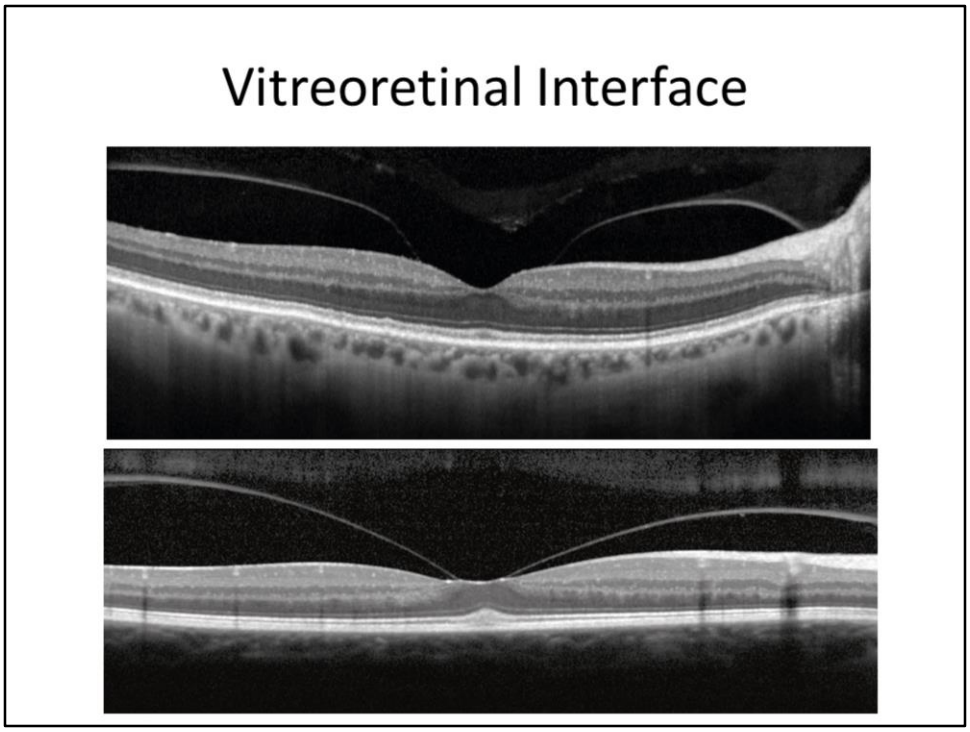
shows a shadowing in the retinal OCT image (highlighted with red arrows) caused by vitreous hemorrhages due to neovascularization of the optic disc (NVD)

Changes in the Foveal Configuration

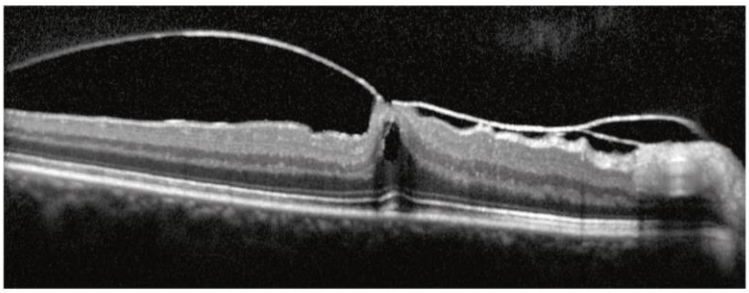


The OCT image through the fovea shows the characteristic depression known as the foveal pit, with the inner retinal layers absent. The photoreceptor layer below the fovea physiologically forms a hump. Thus a slight elevation of the external limiting membrane and the outer segment can be identified.
The continuous, intact nature of the outer retinal layers, including the external limiting membrane, photoreceptors PR1/PR2 and pigment epithelium/Bruch's membrane complex, should be closely examined. The integrity of these structures is often an important indication of the patient's visual acuity and a good determinant of treatment outcomes

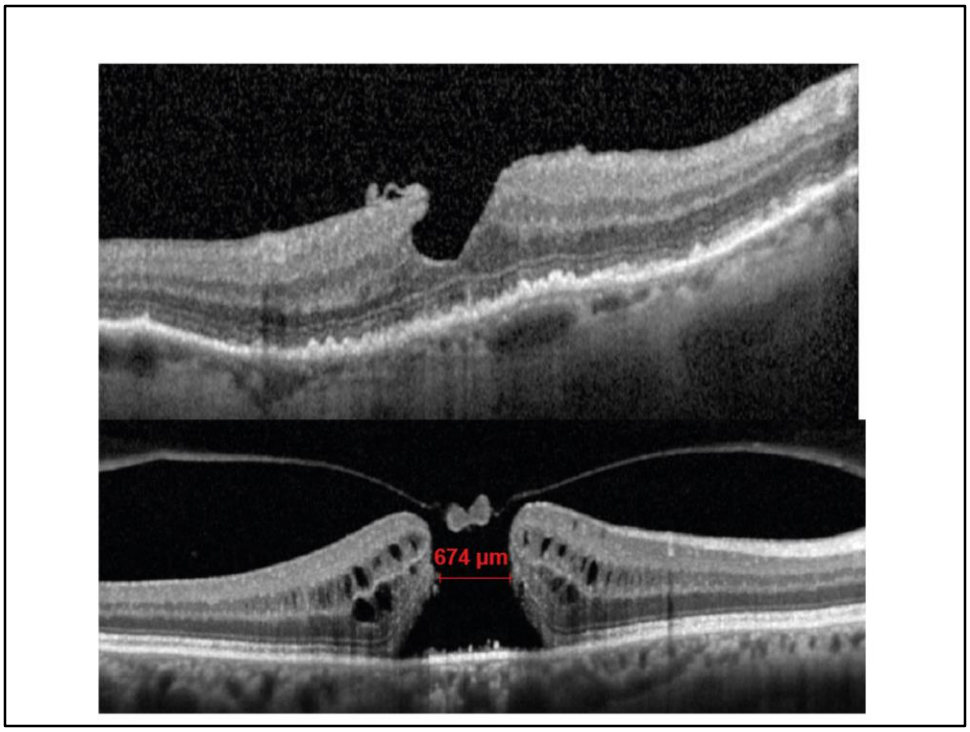
CHANGES IN THE INNER RETINAL LAYERS



VMA vs VMT - In cases where the vitreous body is detached from the retina, the posterior hyaloid membrane may be visualized on the OCT image. It is depicted as a thin, highly reflective line anterior to the internal limiting membrane.
In partial vitreous detachment, where the posterior hyaloid membrane still has its connection to the macula, two stages are differentiated: vitreomacular adhesion (VMA) and vitreomacular traction (VMT). In VMA the attachment of the posterior hyaloid membrane does not lead to intraretinal changes. As soon as intraretinal changes – such as cysts, foramina or subretinal fluid – occur, the attachment is classified as VMT.



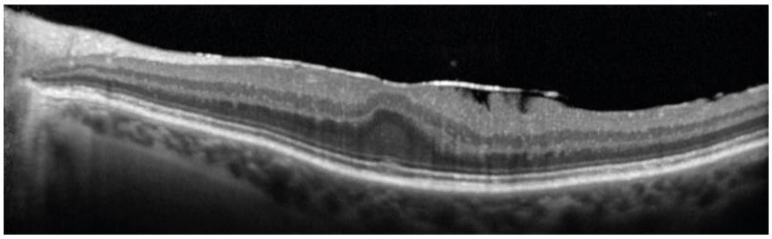
A number of pathogeneses (etiologies both in the metabolism of the vitreous body and the retina) can result in tissue membranes forming between the posterior hyaloid membrane and the internal limiting membrane. These membranes are depicted on OCT images as thickened, highly reflective lines



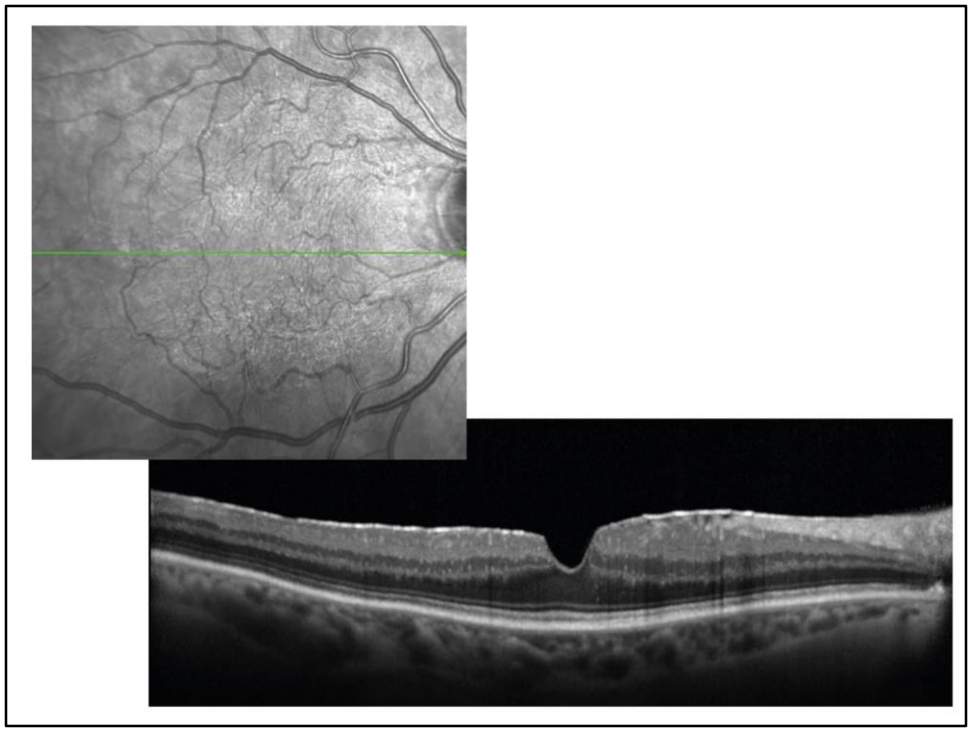
Severe vitreous tractions can cause macular holes. OCT imaging enables the distinction between lamellar macular holes (LMH), full-thickness macular holes (FTMH) and macular pseudo holes (MPH). Fig. 19 shows a lamellar macular hole (LMH) with a partial foveal defect of the inner retinal layers. The foveal contour appears irregular. A LMH can be accompanied by an intraretinal splitting, typically between the OPL and ONL

Full-thickness macular holes (FTMH) are characterized by a complete interruption of all retinal layers from the ILM to the RPE as seen in Fig. 20. FTMHs are classified by size: small (≤250 µm), medium (>250 µm and ≤400 µm) and large (>400 µm)

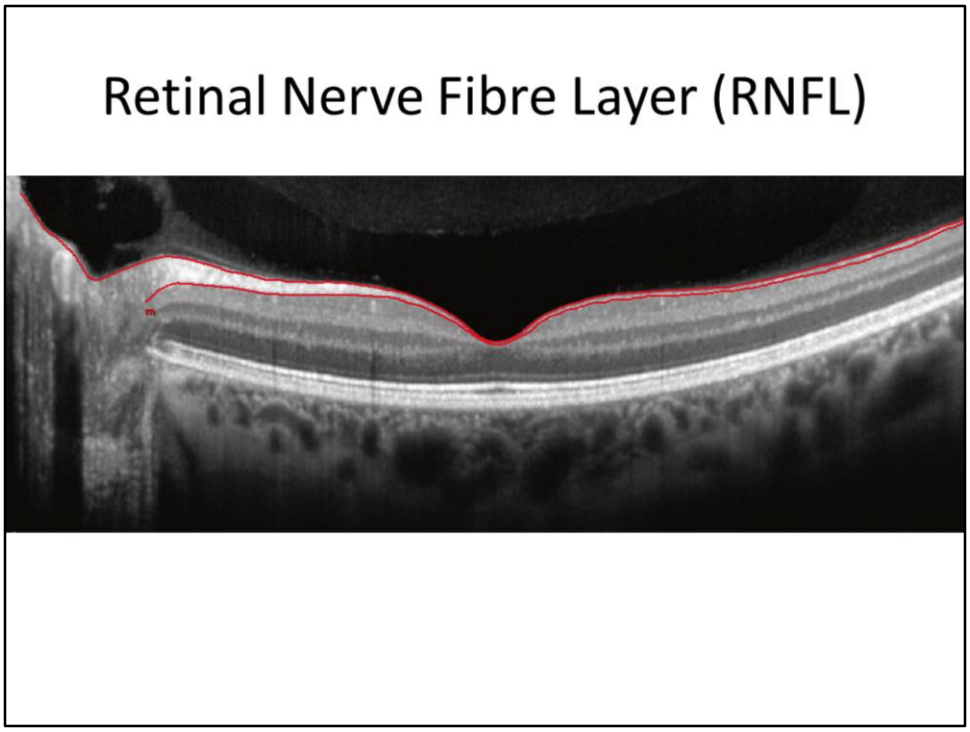
Internal Limiting Membrane (ILM)



Puckerings of the ILM are visualized on OCT images as irregular elevations along the layer, comparable to a panoramic view of a mountain range

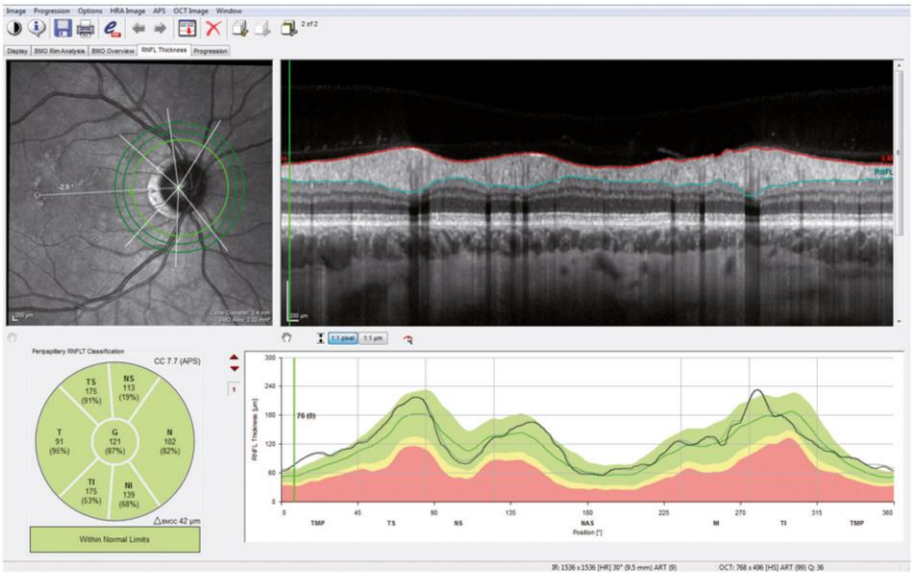


Macular pseudo holes (MPH) are subtypes of epiretinal membranes (ERM). While the ERM causes a thickening in the perifoveal area, the foveola itself is spared from the ERM and appears in a V-shape due to tractive properties of the ERM. The retinal layers do not show any structural loss

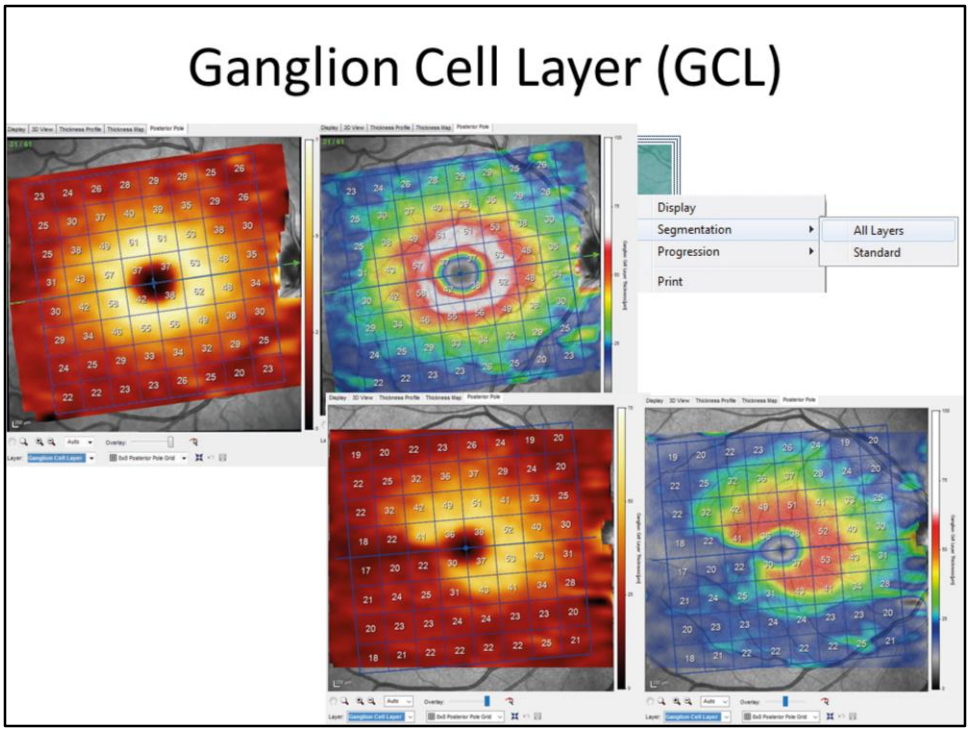


The nerve fiber layer of healthy eyes is visualized on OCT images as a highly reflective layer that becomes increasingly thick as it approaches the optic disc

Retinal Nerve Fibre Layer Thickness



The thickness of the peripapillary nerve fiber layer plays an important role in differentiating healthy eyes from those that are glaucomatous. The RNFLT determined at each point of the circular scan is compared with a reference database and analyzed according to Garway-Heath sectors as well as globally.



In a healthy eye (Fig. 31), the macula is represented by a ring-shaped area of thickened ganglion cell layer. Interruptions (Fig. 32) in this area often indicate thinning and potential loss of the ganglion cells

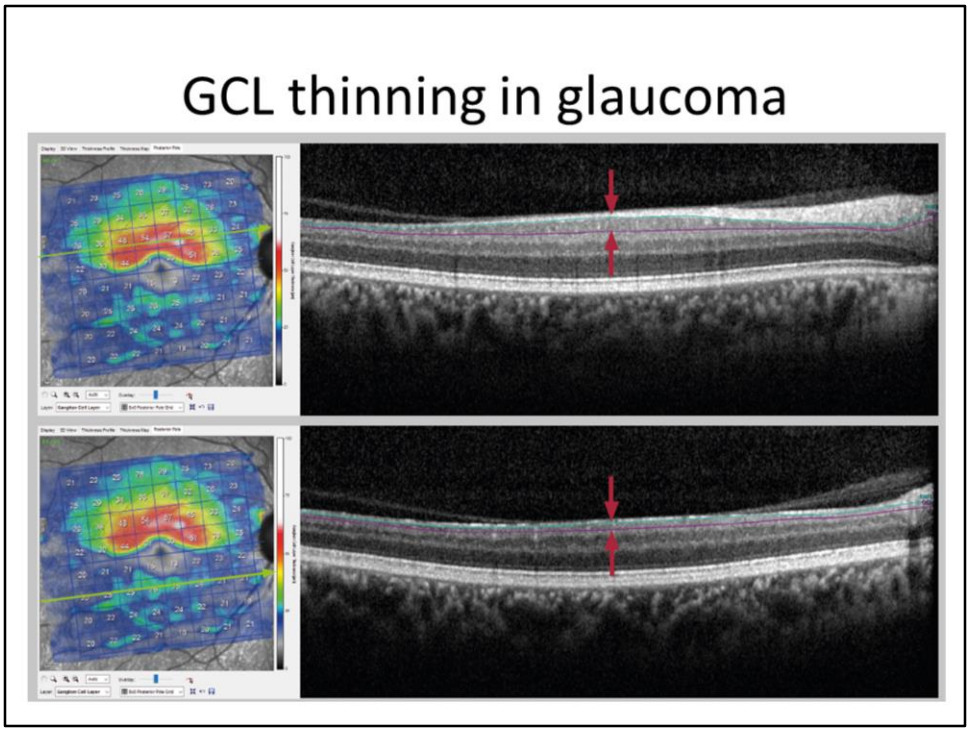
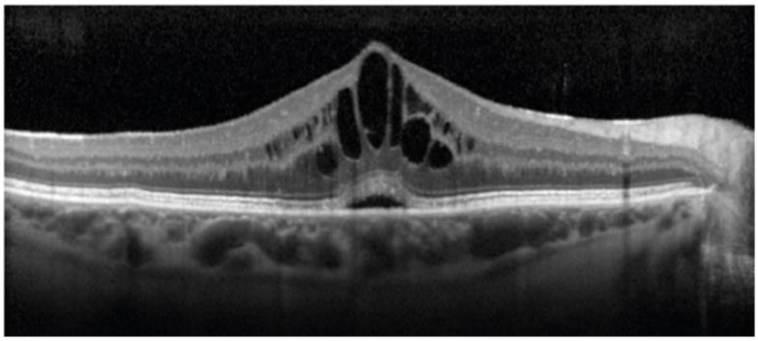


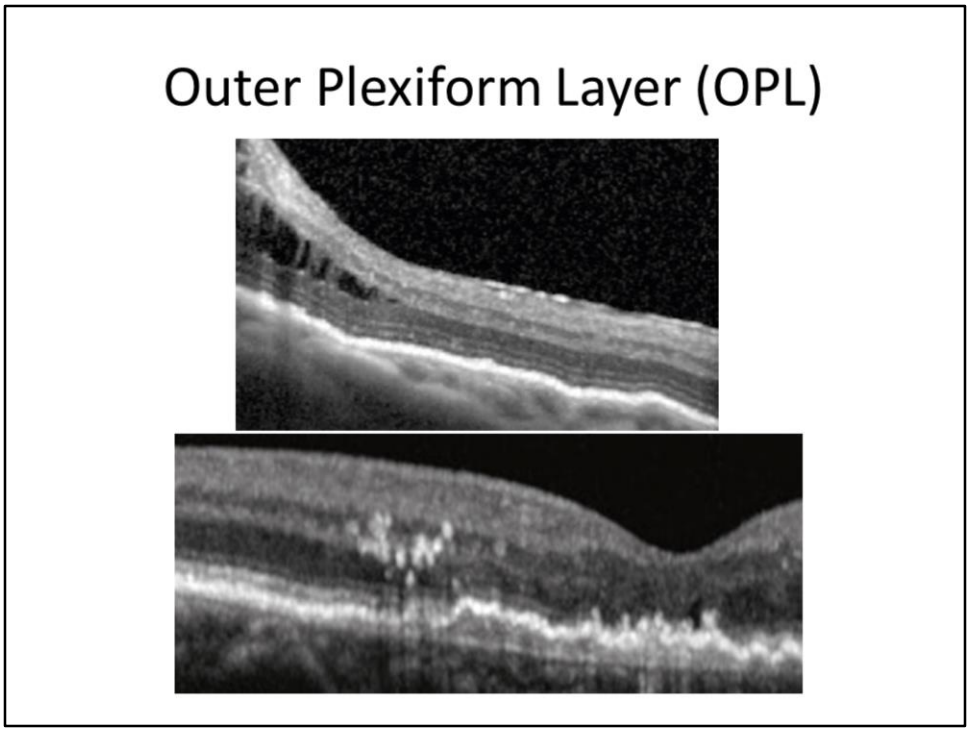
Fig. 33 illustrates an example in which the ganglion cells above the raphe are intact while the ones beneath are seriously damaged. The discrepancy in the thickness of the ganglion cells in the lower and upper hemisphere can also be seen in the OCT image itself.

Inner Nuclear Layer



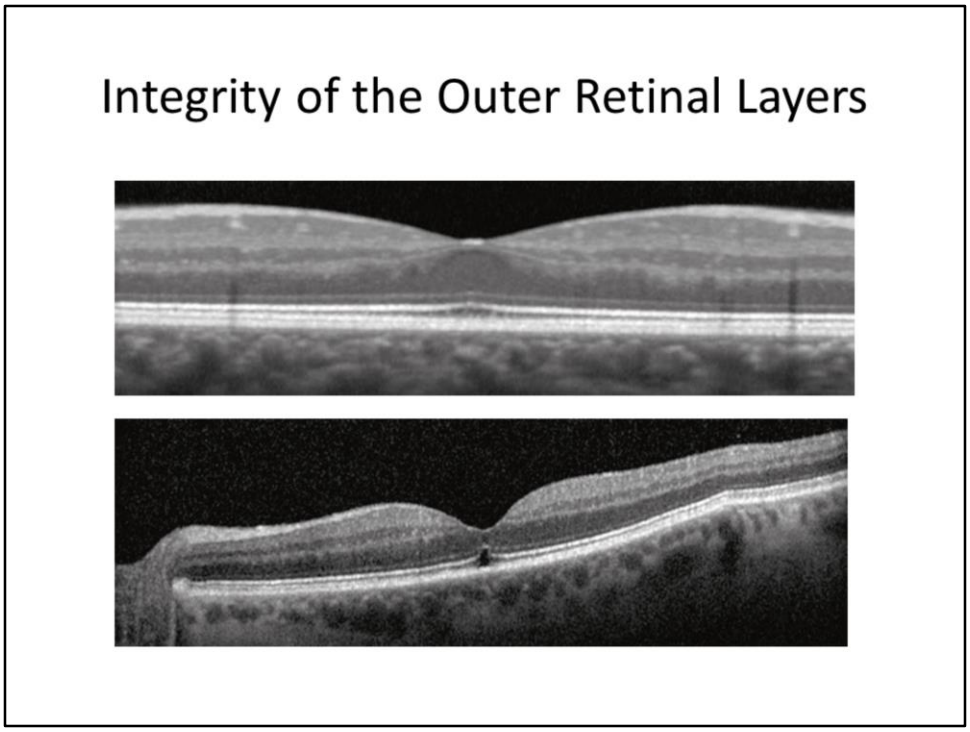
The inner nuclear layer (INL) seems to be susceptible to cystoid fluid accumulations. Depending on the cause, areas of accumulated fluid can be found both foveal and perifoveal

Depending on the pathology, intraretinal fluid accumulation can be detected in different retinal layers. In diabetic macular edema (DME), cysts are commonly limited to the INL and anterior to Henle's fiber layer



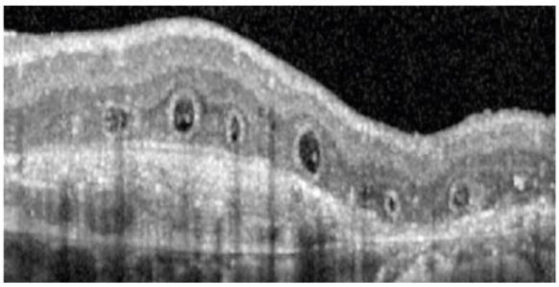
The OPL contains synaptic junctions between the photoreceptors and the bipolar cells. A splitting of the OPL occurs typically in senile retinoschisis. However, retinoschisis can also affect other neuroretinal layers

CHANGES IN THE OUTER RETINAL LAYERS



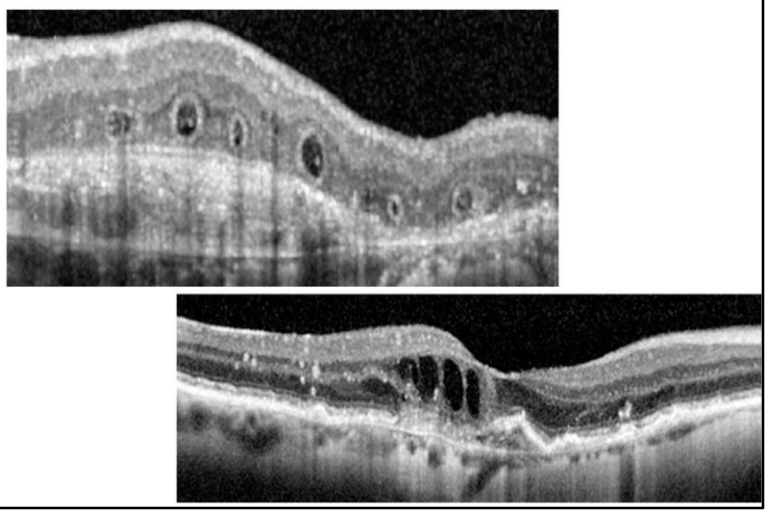
The external limiting membrane (ELM), indicated with red arrows, forms the border between the inner and outer layers of the retina. The main criteria for evaluating the ELM and the bands posterior to it are their continuity and integrity.
The OCT band PR 1 (indicated with orange arrows) forms a small hump in the area of the fovea in healthy eyes.
To ensure full functionality, the OCT band PR1 must be present throughout. Loss of vision often correlates with an interruption of this OCT band. If the OCT band PR1 is completely absent, there is extensive loss of vision

Outer Retinal Tubulations (ORTs)

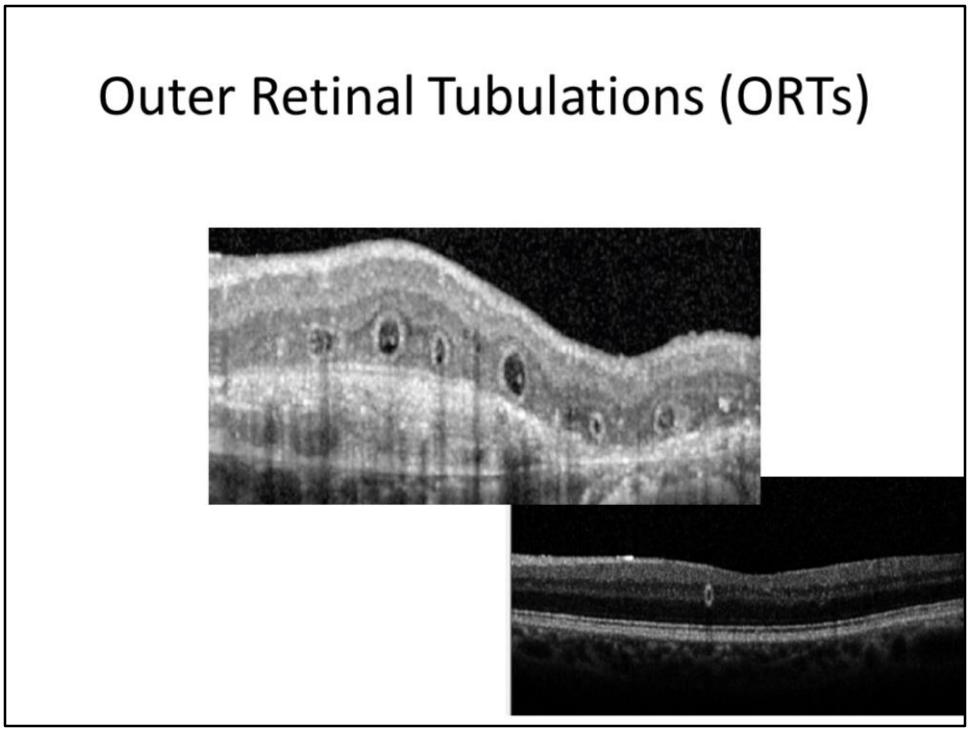


ORTs are seen as a rearrangement of the photoreceptor layers in late AMD. They are characterized as round or oval hyporeflective structures surrounded by a hyperreflective band

Outer Retinal Tubulations (ORTs)



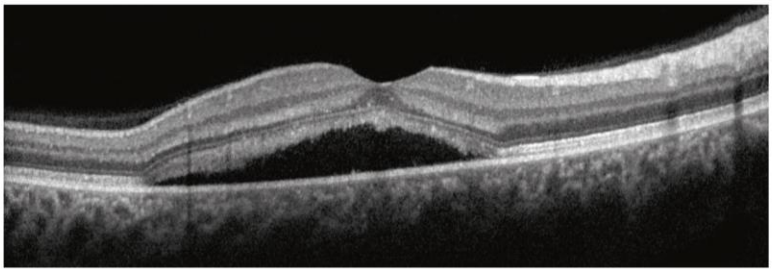
ORTs are seen as a rearrangement of the photoreceptor layers in late AMD. They are characterized as round or oval hyporeflective structures surrounded by a hyperreflective band



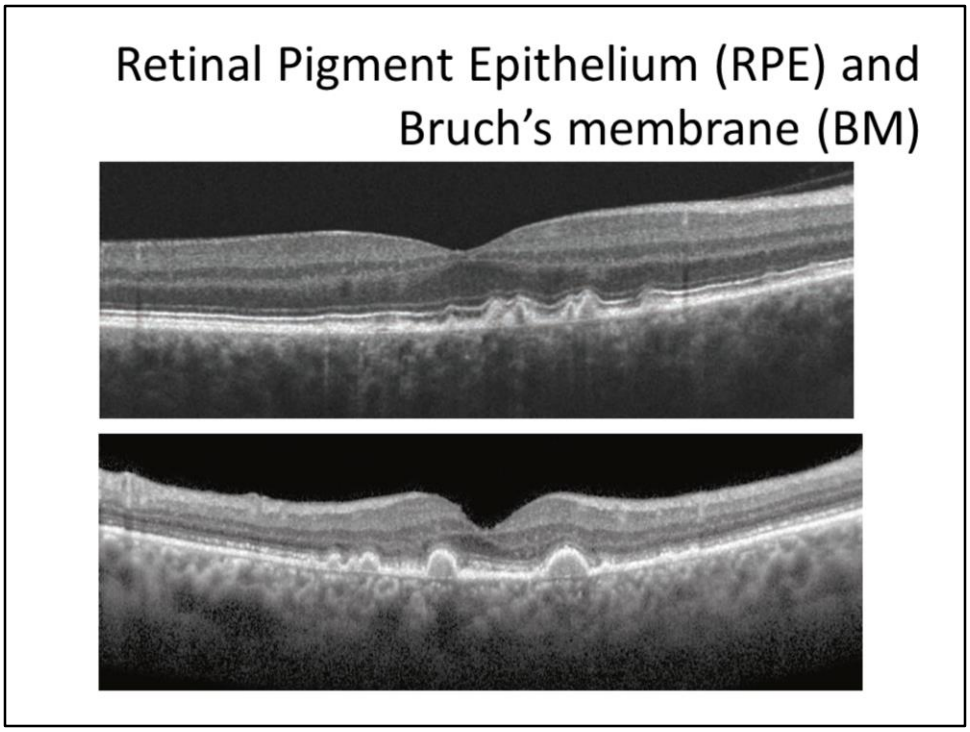
ORTs are seen as a rearrangement of the photoreceptor layers in late AMD. They are characterized as round or oval hyporeflective structures surrounded by a hyperreflective band

CHANGES IN THE SUB-NEURORETINAL/SUB-RPE SPACE

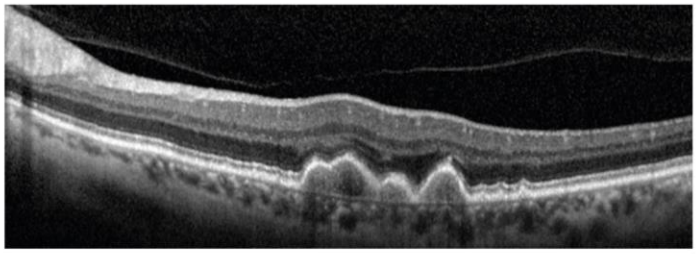
Neurosensory Detachment



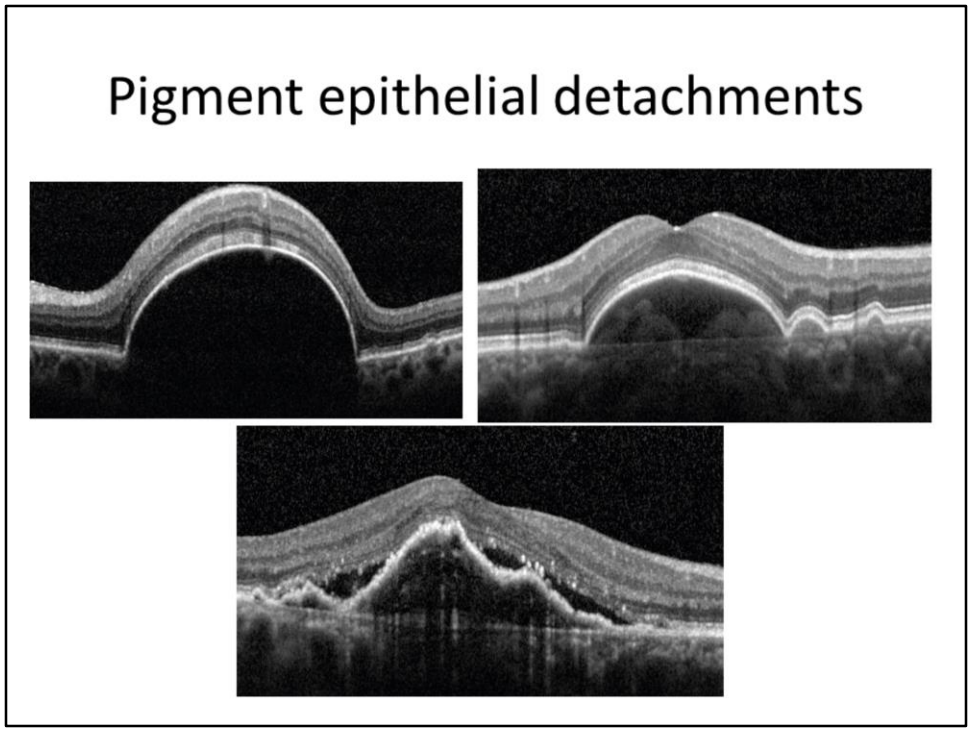
Neurosensory detachments can be distinguished from pigment epithelium detachments on OCT images. Fluorescein angiography is another technology that can be combined with OCT imaging to further aid in diagnosis. Chronic neurosensory detachment typically results in thickening of the photoreceptor layer as seen on OCT images



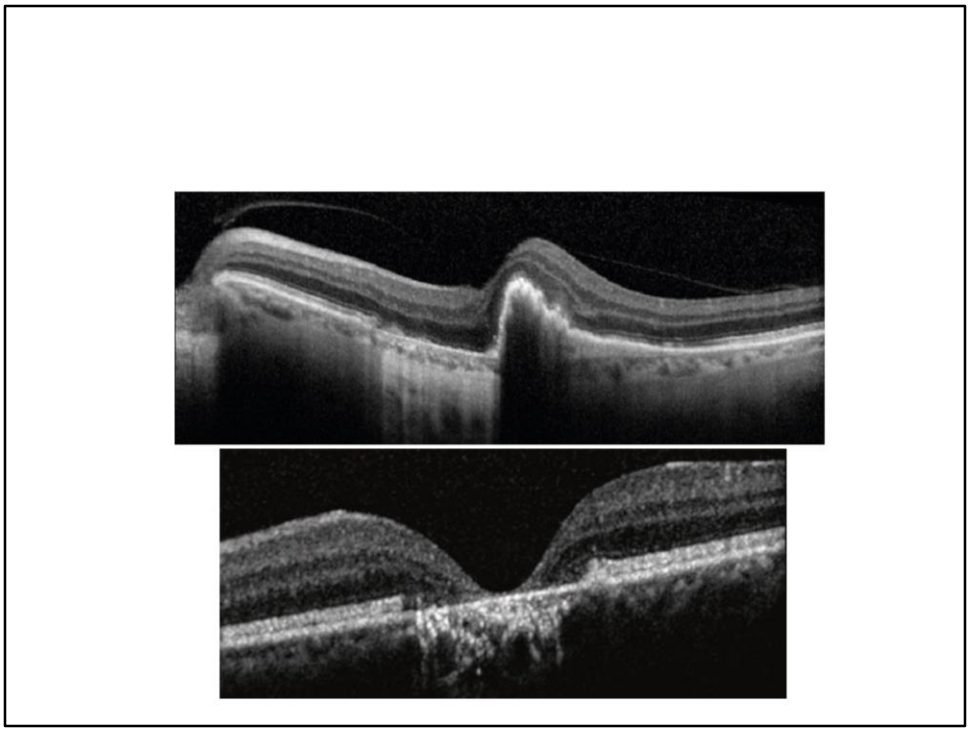
Hard drusen (Fig. 47) appear as dot-like thickened areas or as small circumscribed bulges within the RPE band of the same or lower reflectivity. It is usually easy to define Bruch's membrane as a hyperreflective structure below the drusen. The reflectivity of Bruch's membrane usually remains unchanged
Soft drusen (Fig. 48) appear as wide bulges within the area of the RPE. It is usually easy to define Bruch's membrane as a hyperreflective structure below the drusen. The choroidal reflectivity usually remains unchanged



Drusen can merge over time (Fig. 49). In such cases, they appear as confluent detached areas of RPE and PR1 with unchanged reflectivity from the tissue below them.

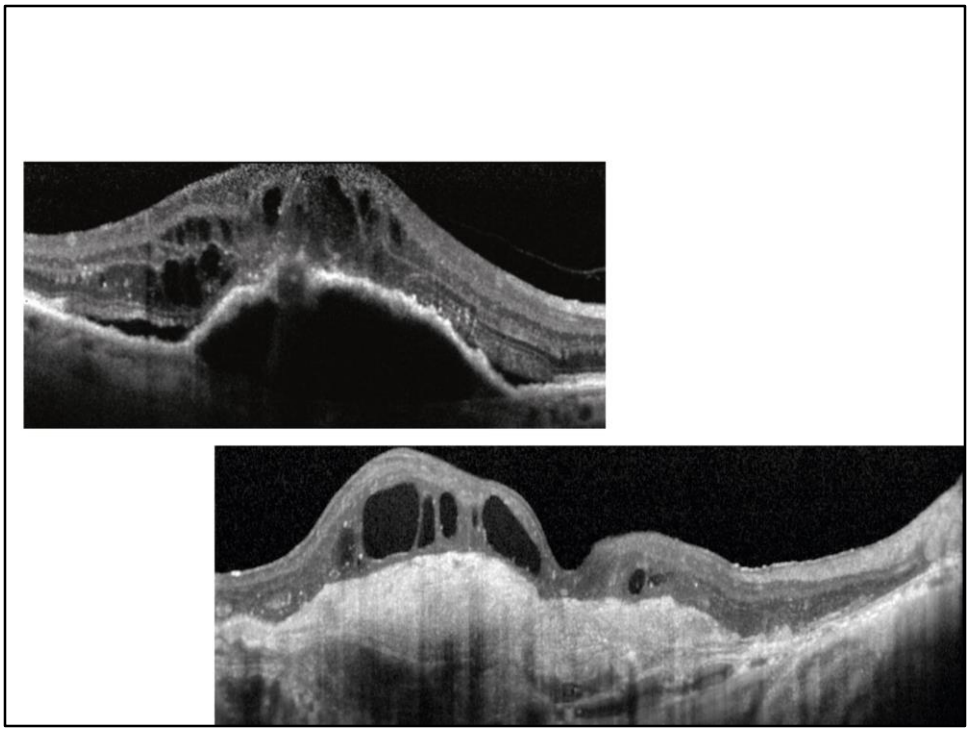


AMD-associated retinal pigment epithelial detachments (PED) can be distinguished as serous, drusenoid or fibrovascular, depending on the type of accumulation between BM and RPE (Fig. 50). Serous PEDs are rare and show an accurately dome-shaped hyporeflective RPE elevation. The space below the RPE appears optically empty (A). In contrast, extracellular drusen materials as well as fibrovascular structures are characterized by solid hyperreflective material beneath the RPE. Fibrovascular PEDs appear inhomogeneous (C), while drusenoid PEDs seem more homogeneous
A tear in the pigment epithelium is best visualized when the OCT scan is placed perpendicular to the tear. At the location of the tear, it is obvious that the RPE band suddenly breaks off. Sometimes the rolled edge of the pigment epithelium can also be visualized



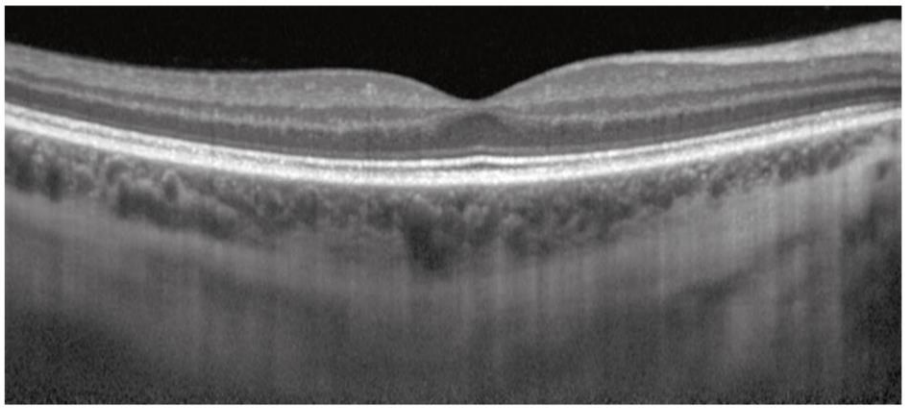
A tear in the pigment epithelium is best visualized when the OCT scan is placed perpendicular to the tear. At the location of the tear, it is obvious that the RPE band suddenly breaks off. Sometimes the rolled edge of the pigment epithelium can also be visualized

Hypopigmentation (loss of pigment epithelium cells and photoreceptor cells) of the RPE increases the contrast of the choroid below it. This is why it is referred to as a window defect



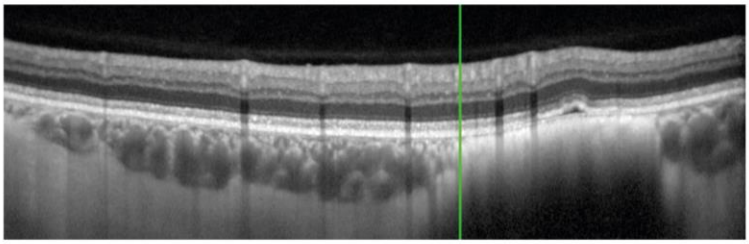
Neovascular membranes consist of newly formed fibrovascular networks that originate in the choroid. In rare cases of retinal angiomatous proliferation (RAP), such membranes may also appear in retinal capillaries. The development of neovascular membranes is visualized on the OCT as an obvious interruption of the RPE
Scars appear as highly reflective, relatively homogeneous thickened areas. If they penetrate multiple layers, the retina's actual layers can no longer be identified (Fig. 57). Cystoid cavities are commonly found in the adjacent layers

Choroid



To analyze the choroid, the EDI (enhanced depth imaging) function should be selected before taking the image. When assessing the choroid using OCT, EDI is mandatory. If using an OCT2 in clinical routine, EDI is not required, since the OCT2 provides high contrast from vitreous to choroid. When using an OCT2, EDI is still recommended for clinical studies

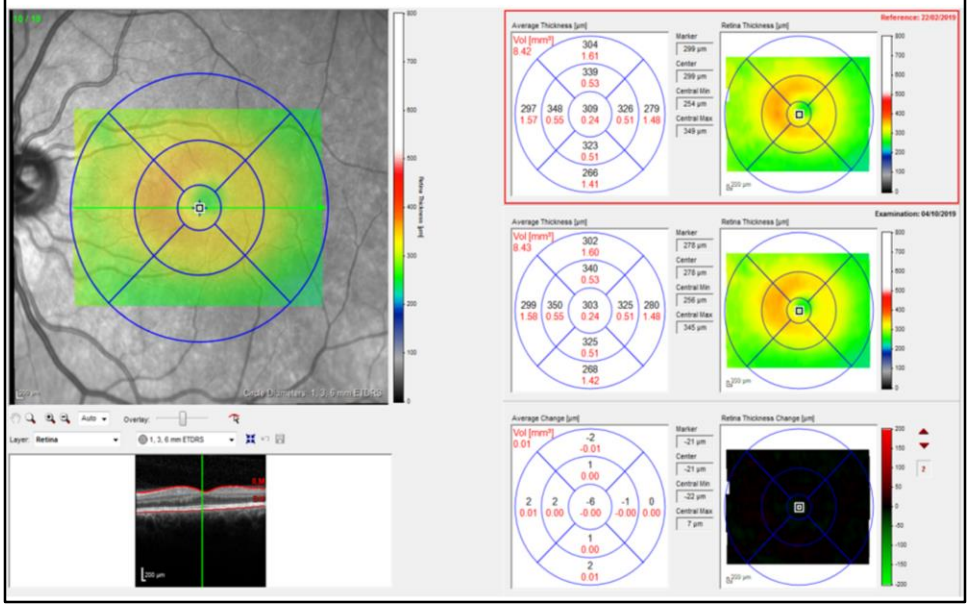
Choroidal naevus



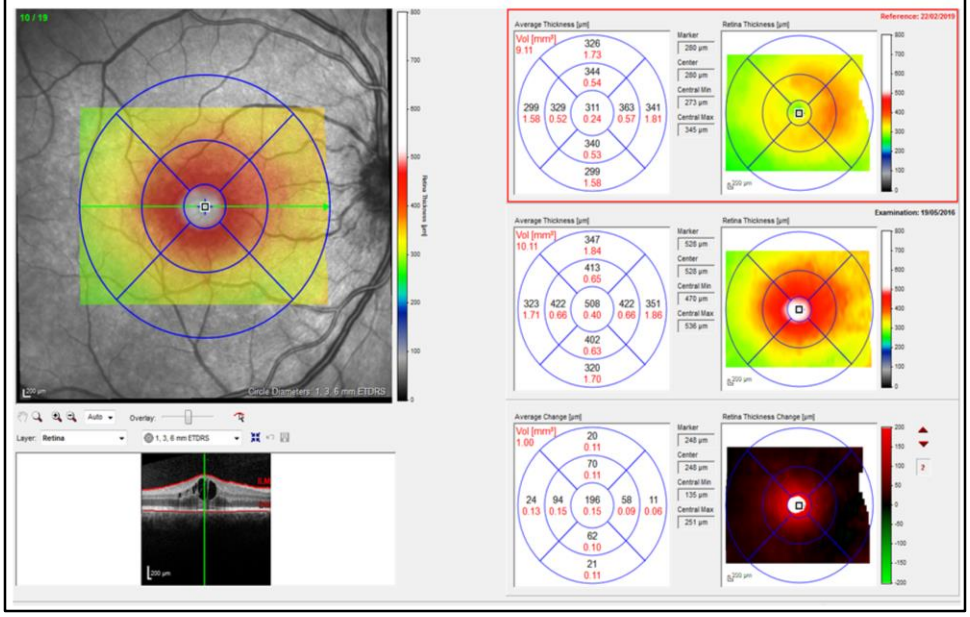
While choroidal nevi are typically seen as hyperreflective areas in the IR image, they appear as light absorbing structures in the OCT image. Tissues beneath the nevus are not visible

QUANTITATIVE ANALYSIS

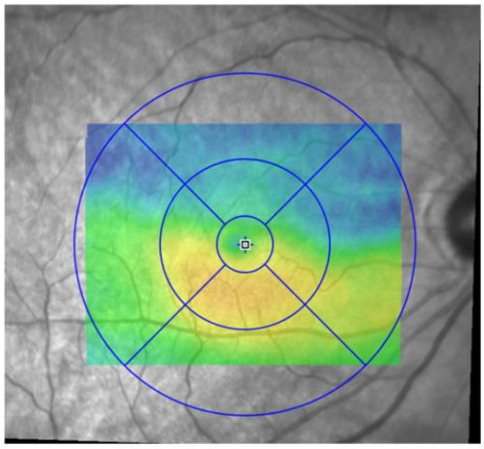
Thickness map

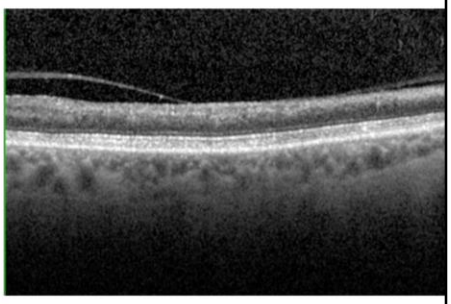


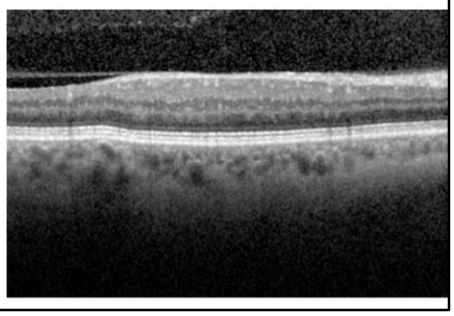
Thickness map



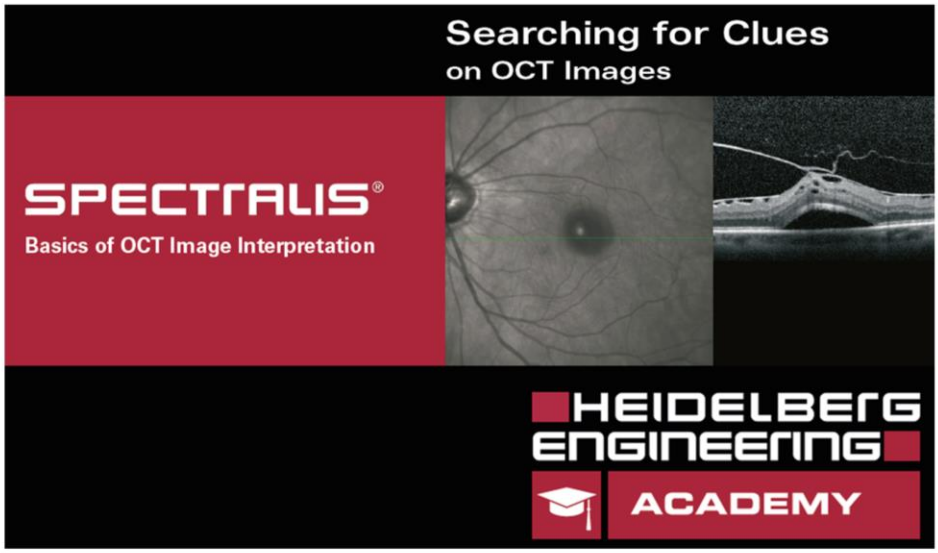
Thickness map







Reference


Searching for Clues
on OCT Images
SPECTRALIS®
Basics of OCT Image Interpretation
HEIDELBERG
ENGINEERING
ACADEMY