Interpreting OCT scans

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Top tips show you how to extract the wealth of valuable information in retinal OCT scans

Optical coherence tomography (OCT) is a safe, non-invasive, fast, reliable test that provides high resolution, cross-sectional images of the retina and vitreoretinal interface. It is an increasingly important tool for the diagnosis and monitoring of a wide range of vitreoretinal conditions.

Current commercial OCT machines use a near infrared broadband light source (not a laser) to illuminate the retina. Differences in echo time and intensity between the reflected light and that from a reference path are measured and converted into three to 10 micron resolution retinal images. This is analogous to the use of sonar waves to image the ocean floor. The resulting image can be considered to be like an optical biopsy of the retinal layers. The layers that appear in an OCT image represent changes in optical reflectance within the retina, which do not necessarily correlate with familiar histological layers.

The latest spectral domain OCT (SD-OCT) machines use complex Fourier analysis techniques to increase signal processing speed, resulting in faster scan acquisition and higher image resolution than is possible with older, time-domain OCT (TD-OCT) systems such as the Zeiss Stratus OCT.

Colour or greyscale

Colour images
Changes in optical reflectance are illustrated in a colour-coded fashion in which warm colours (red, yellow, white) indicate high reflectivity and cold colours (green, blue) indicate low reflectivity.

Greyscale images
Brighter shades are used instead of warm colours to indicate high reflectivity. Absence of reflection appears black.

Greyscale images are better than colour images for visualising epiretinal membranes (ERM), photoreceptor (PR) and retinal pigment epithelium (RPE) morphology. Colour images can be misleading as the displayed colours are false colours and dramatic changes in colour can be misinterpreted as large changes in OCT reflectivity.

Normal macula OCT scan
Familiarity with the appearance of a normal macular OCT scan (Figure 1) is important to confidently identify pathological changes. Features to note (from anterior to posterior) include:
- The anterior signal originates from the inner limiting membrane (ILM) and retinal nerve fibre layer (RNFL). This has a smooth, relatively flat outline peripherally and a characteristic central dip at the fovea (referred to as the foveal pit).
- Posterior to the ILM/RNFL, subtle changes in reflectance are seen as alternating bands of hyper- (lighter) and hypo- (darker) reflectance representing the ganglion cell bodies, the inner plexiform, inner nuclear, outer plexiform and outer nuclear layers.
- Posterior to the outer nuclear layer, a series of three adjacent and increasingly hyper-reflective lines may be visible, representing the external limiting membrane (ELM), photoreceptor inner segment/outer segment junction (IS/OS junction), and RPE. A focal elevation of the ELM and IS/OS junction lines beneath the foveal pit is normally present. The ELM and IS/OS junction lines are often absent in SD-OCT scans of suboptimal image quality and in older TD-OCT scans.
- The signal posterior to the RPE arises from the choroid as patchy areas of high reflectivity.

Figure 1. Greyscale SD-OCT scan of a normal macula

Figure 2. Macular thickness map showing macular oedema due to wet AMD
Protocols for assessment
The most useful scanning protocols for assessing vitreoretinal disease are:

High-resolution line scan
This is a single high-resolution cross sectional scan, typically passing through the foveal centre, although the position of the scan can be changed to image areas of focal pathology outside of the fovea. This type of scan is good for making a diagnosis and assessing the retinal layers in detail (Figure 1).

Composite thickness map
This is a topographical display providing quantitative information about the thickness of the retina in a colour-coded map (Figure 2). Warm colours (red, yellow, white) indicate areas of thicker retina and cold colours (green, blue) indicate areas of thinner retina. The normal macula thickness is approximately 150 to 250 microns; this figure varies according to the specific machine and manufacturer’s normative database. Thickness maps are good for quickly identifying and localising areas of diffuse retinal pathology that may be missed on individual high resolution line scans. The quantitative data provided by serial thickness maps is useful for monitoring progress and response to treatment over time, particularly in conditions such as macular oedema associated with diabetic retinopathy, retinal vein occlusions, ERM or choroidal neovascularisation associated with wet age-related macular degeneration (AMD)(Figure 3).

Top interpreting tips
Be systematic in your approach to reviewing OCT scans. I typically start by reviewing the macular thickness map to gain a quick overall view of the macular topography. Look for areas of retinal thinning (often associated with atrophic AMD, high myopia or chorioretinal scarring) or thickening (commonly associated with epiretinal membranes, wet AMD or macula oedema due to retinovascular disease) (Figure 2).

Next, I look at the high resolution line scans in greyscale, specifically reviewing each anatomical layer from anterior to posterior looking for the following:

1. Posterior vitreous face
This is a thin, curved or horizontal line of hyper-reflectivity visible anterior to the retinal surface. It is often not visible if the vitreous is still completely attached to the macula or if it has detached anteriorly beyond the area visualised by the OCT scan. When visible, the vitreous face may be completely detached from the macula or partially detached with residual attachment to the central macula and fovea; this is a common normal appearance called a perifoveal posterior vitreous detachment and represents the early stages of a posterior vitreous detachment (Figure 5).

If the attachment between the vitreous and the fovea is abnormally strong, pathological changes due to vitreomacular traction may be visible as a change in the shape of the normal foveal pit (the pit may be absent, shallower than usual, irregular or have underlying cystic structures visible) or splitting/cystic changes within the neurosensory retina (Figure 6). Advanced vitreomacular traction can lead to a full-thickness defect in the central neurosensory retina known as a macular hole (Figure 7).

2. Vitreoretinal interface
Look at the anterior surface of the retina for features of an epiretinal membrane (ERM). These are common and identified as a distinct hyper-reflective line in close contact with the retinal surface. ERMs can cause a wrinkling of the retinal surface, which can be visible as irregular saw-tooth shaped undulations in the retinal surface. ERMs may cause a reduction in depth or even complete loss of the normal foveal dip (Figure 8).

En face and 3D scans
These provide impressive-looking images demonstrating the three-dimensional appearance of the vitreoretinal interface, which can be useful for educating patients and spicing up lecture presentations. Their clinical usefulness is relatively limited (Figure 4).

Figure 3. Macular thickness map showing partial resolution of macular oedema following intravitreal anti-VEGF treatment for wet AMD (same eye as in Figure 2)

Figure 4. Three-dimensional macular scan showing vitreomacular traction

Figure 5. Perifoveal posterior vitreous detachment

Figure 6. Vitreomacular traction with secondary foveal cyst

Figure 7. Full thickness macular hole due to vitreomacular traction. Free-floating operculum visible anterior to macular hole.

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3. Neurosensory retinal layers
Qualitatively assess the thickness, regularity and continuity of the retinal layers. Look specifically for hyporeflective cystic changes indicating fluid that may be intraretinal, subretinal (between the neurosensory retina and the RPE) or sub-RPE (below the RPE). Common causes of cystic fluid accumulation include wet AMD (Figure 9), diabetic macula oedema and retinal vein occlusions. Exudates may be seen as focal areas of hyper-reflectivity within the neurosensory retina in diabetic maculopathy, retinal vein occlusions and wet AMD.

4. IS/OS junction
Specifically assess the visibility and continuity of the IS/OS junction because the integrity of this structure often correlates with visual acuity in many retinal conditions. If the IS/OS junction is clearly visible and unbroken, the visual acuity is often good but if the IS/OS junction is disrupted, the visual acuity is often correspondingly poor (Figure 10). Thus the IS/OS junction can be considered to be a surrogate marker for retinal photoreceptor viability and provides prognostic information in monitoring or predicting response to treatment of conditions such as epiretinal membranes or wet AMD.

5. RPE
Look for areas of elevation, variation in thickness (thickening or thinning), and fluid above or below the RPE or discontinuity. AMD is associated with a wide variety of RPE changes on OCT, such as drusen appearing as small dome-shaped protuberances in the RPE (Figure 11), pigment epithelial detachments (PED) seen as larger dome-shaped elevations, fibrosis (areas of RPE thickening) atrophy (area of RPE thinning). Central serous retinopathy (CSR) is often associated with small PEDs, typically in association with overlying subretinal fluid (Figure 12).

The choroid is poorly visualised with current generation OCTs but future machines will achieve greater choroidal resolution, enabling changes in conditions such as degenerative myopia, CSR, PCV and inflammatory choroidopathies to be analysed.

6. Assess quality of scan, look for common artifacts
Poor-quality scans may appear grainy, irregular in contour, colour and intensity, and may result from ocular surface disease (dry eyes, blepharitis, corneal disease), poor fixation, small pupils or extreme refractive error. Prior to performing an OCT scan, the ocular surface should be examined, the patient should be asked to blink, artificial tear-drops may be used in patients with dry eye, and fixation should be monitored or assisted with the use of an external fixation light.

Review scan placement (is the fovea centred or does the scan include the area of pathology?) and algorithm performance (do the computer-generated boundary lines used to calculate retinal thickness correlate with ILM/PR location?).

Movement artifacts are common due to poor fixation, poor patient co-operation or nystagmus, and appear as an undulating irregular appearance of all retinal layers. Shadow artifacts posterior to retinal vessels are a common and unavoidable feature of many normal scans.

Conclusion
OCT scanning provides detailed qualitative and quantitative information about the retinal structure in a wide range of retinal conditions. A familiarity with the appearance of a normal OCT scan and a systematic approach to evaluating retina OCT scans will enable practitioners to glean the maximum amount of clinically useful information when interpreting OCT scans.