Optical coherence tomography (OCT) is a non-contact and non-invasive high resolution technique for imaging of partially transparent objects. It has found a wide spectrum of applications in biomedical imaging, especially in ophthalmology.1,2

The technique is analogous to ultrasound, except that it uses light waves rather than sound waves. OCT offers information about the depth structure of a sample using interferometry of temporally low coherent light at a wavelength of approximately 840nm. Since the introduction of the OCT in 1991, this revolutionary technology has constantly improved its design with more advanced imaging modalities and acquisitions. There are two variants of OCT techniques depending on the detection system: time-domain, such as the Stratus OCT 3 (Carl Zeiss Meditec) and frequency-domain as found in the Spectralis HRA+OCT (Heidelberg Engineering, Haag-Streit UK distribution). Frequency-domain provides a significant improvement of imaging speed and detection sensitivity.3 The aim of this paper is to show the advanced applications of the Spectralis HRA+OCT in a clinical setting.

The Spectralis HRA+OCT (Figure 1) provides a unique combination of retinal angiography and optical coherence tomography. The Spectralis HRA+OCT comes with six different acquisition modes (Figure 2). OCT, fluorescein angiography (FA) and indocyanine green angiography (ICGA) are the three main ones. Additionally, it enables multimodality imaging where any two modalities can be used simultaneously. Simultaneous dual-beam imaging also allows infrared fundus imaging, where high-resolution black and white images reveal advanced details and structures of the inner eye. The red-free and fundus-autofluorescence modalities are especially designed to enhance imaging during fluorescein angiography and indocyanine green angiography. For optometrists in a clinical setting, the retinal angiography modes might not be a necessity; Heidelberg also offers Spectralis versions without this mode (Spectralis OCT or Spectralis OCTplus). New software has been released with features listed in Table 1.

Eye tracking

The Spectralis HRA+OCT has one main advantage compared to the other available OCT devices. It uses an integrated confocal laser fundus imaging technique to guide the OCT scan and introduce eye tracking, by using two separate beams of light (820 and 870µm) to capture two images simultaneously at 40,000 A-scans per second. One beam acts as a reference, guiding the second beam of light during real-time, cross-sectional scanning and keeping it correctly positioned as the eye moves. This technique enables high precision and repeatability. Compared to other available OCT instruments, the Spectralis HRA+OCT presented very low coefficients of variation for repeated measurements, which makes the instrument highly repeatable. Additionally, it showed the smallest variability, which equates to the smallest measurable change of 3µm, when compared to other OCT instruments (between 7 and 16µm).4

Axial resolution has shown the greatest improvement over time with various imaging techniques. The axial resolution of the Spectralis instruments achieved a 7.0µm optical resolution and a 3.9µm digital resolution, which is again an improvement compared to the Topcon 3D OCT-1000 of Topcon (5µm). Figure 3 and Figure 4 show cross-sectional images obtained with the Spectralis, showing all retinal layers in high definition. The Spectralis outperforms previously developed 3D OCT instruments in terms of the scanning speed (0.019 compared with 0.05 seconds per scan). Other additional advantages to this new technique include tracking changeover time and noise reduction. The instrument will not only use the baseline fundus image as its guide during the first OCT scan, but uses its location in any follow-up scans as well. It will automatically place any future scans in the exact same location, which eliminates any subjective placement error (Figure 5). This feature will improve its disease assessment overtime and helps to improve any treatment decisions. The noise reduction, also known as the real-time (ART) function, produces...
higher quality images with finer details, based on combining multiple images of the same location and filters out any random noise which was not present in every image in the entire dataset. The confocal microscope, which suppresses the signal anteriorly and posteriorly to the confocal plane of interest, will also reduce the interference with anterior anatomical structures such as the crystalline lens.

Use in practice
The use of the Spectralis instrument is fast and easy for both the observer and the patient. Due to the eye tracking system, the acquisition of the OCT scan might take a bit longer than other frequency domain OCTs. No dilation is needed while the patient is asked to place their chin and head against the rest and look at the blue internal fixation target. The following parameters can be changed on the control panel: intensity of IR (25–100 per cent in steps of 25 per cent); width of the scan (15, 20, or 30 degrees); and either section scan (single line, circular, radial) or a volume scan. The Spectralis allows the operator to customise the volume scanning protocol by adjusting the scan density and the dimensions of the scan area. From each volumescan, the Spectralis generates a default retinal thickness map, RNFL thickness map, and progression map. These imagescanbedisplayed for example in colour spectrum red (enhanced viewing of intra-retinal layers) or blue (enhanced detail around the RPE). Other viewing options are available, such as colour (heat and high frequency) or grey scales (positive and negative), which can all be viewed in 2D or 3D.

Conclusion
Management and treatment of retinal diseases has improved dramatically over the past several decades and this has mainly occurred as imaging techniques became more advanced. Retinal thickness changes and the presence of fluid are the two most important parameters in the follow up of retinal diseases.

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>The new Spectralis Software Version 5.1b released last week</td>
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<tr>
<td>☑️ Redesigned acquisition window with multiple preset OCT scan patterns and scan parameter settings</td>
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<tr>
<td>☑️ ‘AutoRescan’ function across different imaging modes</td>
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<tr>
<td>☑️ Improved automatic image brightness control on all Spectralis models</td>
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<td>☑️ Significantly extended OCT tracking time</td>
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<tr>
<td>☑️ Orientation adjusted normative database for RNFL analysis</td>
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<td>☑️ RNFL thickness progression printout</td>
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<tr>
<td>☑️ Advanced follow-up examination management</td>
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<tr>
<td>☑️ Improved segmentation line editing</td>
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<tr>
<td>☑️ Free 90-day trial of the Scan Planning Tool</td>
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</table>

Spectralis instruments are pre-installed with remote viewing capabilities that enable clinicians to review images at their PC or even display them on large monitors for educating patients. The software produces a retinal thickness map, RNFL thickness map, and progression map. These images can be displayed in colour spectrum red (enhanced viewing of intra-retinal layers) or blue (enhanced detail around the RPE). Other viewing options are available, such as colour (heat and high frequency) or grey scales (positive and negative), which can all be viewed in 2D or 3D.

Conclusion
Management and treatment of retinal diseases has improved dramatically over the past several decades and this has mainly occurred as imaging techniques became more advanced. Retinal thickness changes and the presence of fluid are the two most important parameters in the follow up of retinal diseases.
which needs high reproducibility of any imaging technique. The Spectralis HRA+OCT has shown high repeatability and reproducibility in normal subjects when compared to other available OCT devices, with dramatic advances in virtual every aspect of imaging retinal diseases, due to its multimodality imaging, eye-tracking and noise reduction.

Acknowledgement
Thanks to Haag Streit UK for loan of the instrument to the Fight for Sight Optometry Clinic, City University. For more details on Spectralis telephone Haag Streit on 01279 456261.

References

Dr Byki Huntjens is a lecturer at City University and has no commercial interests in any product described.

Figure 6 Output report looks very similar to those from other OCT instruments


AMD or ERM?

Ophthalmologist James Talks describes a case illustrating how use of the OCT makes differentiation of an epiretinal membrane from potential wet AMD possible.

A 60-year-old man complained of mild distortion in his left eye. He had previously had peripheral laser treatment for the development of retinal new vessels secondary to ocular ischaemia six years ago. His visual acuity was 6/6 OD and 6/12 OS. A distorted macular retinal pattern was noted on clinical examination as well as old peripheral laser marks and fibrosed new vessels. A red free image shows a wrinkled retinal surface. OCT imaging shows a dark band of thickening on the retinal surface consistent with a diagnosis of an epiretinal membrane (ERM).

The symptom of distortion is suggestive of macular pathology and there can be concern that this is due to wet macular degeneration that might benefit from urgent treatment. An OCT image is very useful to detect if there is any disturbance of the macula and can often make the diagnosis.

In this case the disturbance of the retina is on the inner surface whereas the underlying retinal pigment epithelium and external limiting membrane is unaffected. This demonstrates that it is unlikely to be macular degeneration, which usually affects the retinal pigment epithelium first, with thickening developing underneath the retinal nerve fibres (see figure, obtained using the Spectralis OCT).

Epiretinal membranes, also known as cellophanemaculopathy when it is mild, like a piece of cling film on the retina, or macular pucker when it is causing more significant visual symptoms, can often be idiopathic but are associated with other disturbances of the retina such as from a peripheral retinal tear, previous retinal laser or retinal detachment surgery. There has often been a posterior vitreous detachment. After an initial period of growth the majority will remain stable. Surgery can be indicated if the patient is very symptomatic from distortion and reduced vision.

James Talks is consultant ophthalmologist and head of department at Royal Victoria Infirmary, Newcastle-upon-Tyne.