Swept Source Optical Coherence Tomography

Compendium

Introduction

This research compendium aims to provide clinicians with an overview of the latest peer reviewed research on swept source OCT technology. In addition to the scientific abstracts, the compendium provides a link, allowing the user to access the full paper (subject to permission), along with brief notes on the clinical relevance of each paper with respect to swept source technology. The document is regularly updated and every endevour is made to ensure that all relevant available papers are included, however this cannot be guaranteed.

The papers in this compendium predominantly employ a swept source OCT prototype or the swept source DRI OCT-1 Atlantis*. Papers using the recently released DRI OCT Triton* (also swept source) will be added as they are published. No other swept source OCT instruments are commercially available at this time.

Swept source technology has the advantage of maintaining a good signal to noise ratio with increased tissue depth, resulting in clear images of the choroid and sclera without the loss of vitreous detail. This, combined with greater light penetration associated with a 1um light source, provides information from deeper structures, with potential advantages for the diagnosis and management of particular ocular conditions such as pathological myopia and diseases affecting the choroid and sclera. The long wavelength light source also improves the penetration of media opacities such as cataract and hemorrhage.

* Not available in all countries, please check with your local distributor for availability

* Not Available for Sale in the United States

Last update: December 2015

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Agawa T, Miura M, Ikuno Y, Makita S, Fabritius T, Iwasaki T, et al. Choroidal thickness measurement in healthy Japanese subjects by three-dimensional high-penetration optical coherence tomography. Graefe's Archives for Clinical and Experimental Ophthalmology. 2011 Oct;249(10):1485-92. 30

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Swept Source Optical Coherence Tomography -

Clinical Performance

Yasuno Y, Miura M, Kawana K, Makita S, Sato M, Okamoto F, et al. Visualization of sub-retinal pigment epithelium morphologies of exudative macular diseases by high-penetration optical coherence tomography. Investigative Ophthalmology and Vision Science. 2009 Jan;50(1):405-13.

Purpose: To evaluate the clinical significance of the newly developed long-wavelength probe optical coherence tomography (LP-OCT) for the diagnosis of exudative macular diseases.
Methods: Fourteen eyes of 13 participants were prospectively enrolled in the study. There were seven type I and five type II choroidal neovascularization (CNV) cases associated with age-related macular degeneration and idiopathic neovascularization and one case of polypoidal choroidal vasculopathy (PCV). A custom-built LP-OCT based on swept-source OCT (SS-OCT) technology was used. This new OCT uses a probe beam with a wavelength of 1060 nm that provides deeper penetration into the choroid and higher image contrast to the structures beneath the retinal pigment epithelium (RPE) and pathologic tissues than does conventional OCT. The depth resolution is 10.4 micron in tissue and the measurement speed is 28,000 depth scans/s. All the eyes were also examined by standard short wavelength probe OCT (SP-OCT). The image contrasts of the LP- and SP-OCT were qualitatively evaluated and analyzed by Wilcoxon's paired signed rank test and Spearman's rank correlation test.
Results: In 10 of 14 eyes, high-contrast visualization of the diseases beneath the RPE, CNV, or fibrin was attained. These diseases were almost invisible in the SP-OCT images. The LP-OCT of the remaining eyes also revealed significant improvement in the image contrasts beneath the RPE and CNV. Qualitative evaluation of the image contrasts and subsequent statistical test indicated statistically significant improvement in the image penetration to the choroid of LP-OCT to that of SP-OCT.
Conclusions: LP-OCT provided significant improvement in the image contrast of exudative macular diseases.

Significance: One of the first articles describing the advantages of SS-OCT using a longer wavelength to image pathological structures beneath the RPE – an area that is very difficult to visualize with spectral domain OCT because of the absorption of shorter wavelength light by the melanin within the RPE, and the loss of signal to noise ratio with increased image depth. Note that swept source technology has moved on, particularly in terms of speed and the amount of data collected, since this early prototype.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2125860

Mansouri K, Medeiros FA, Tatham AJ, Marchase N, Weinreb RN. Evaluation of retinal and choroidal thickness by swept-source optical coherence tomography: repeatability and assessment of artifacts. American Journal of Ophthalmology. 2014 May;157(5):1022-32.

Purpose: To determine the repeatability of automated retinal and choroidal thickness measurements with swept-source optical coherence tomography (SS OCT) and the frequency and type of scan artifacts.
Design: Prospective evaluation of new diagnostic technology.
Methods: Thirty healthy subjects were recruited prospectively and underwent imaging with a prototype SS OCT instrument. Undilated scans of 54 eyes of 27 subjects (mean age, 35.1 ± 9.3 years) were obtained. Each subject had 4 SS OCT protocols repeated 3 times: 3-dimensional (3D) 6 × 6-mm raster scan of the optic disc and macular, radial, and line scan. Automated measurements were obtained through segmentation software. Interscan repeatability was assessed by intraclass correlation coefficients (ICCs).
Results: ICCs for choroidal measurements were 0.92, 0.98, 0.80, and 0.91, respectively, for 3D macula, 3D optic disc, radial, and line scans. ICCs for retinal measurements were 0.39, 0.49, 0.71, and 0.69, respectively. Artifacts were present in up to 9% scans. Signal loss because of blinking was the most common artifact on 3D scans (optic disc scan, 7%; macula scan, 9%), whereas segmentation failure occurred in 4% of radial and 3% of line scans. When scans with image artifacts were excluded, ICCs for choroidal thickness increased to 0.95, 0.99, 0.87, and 0.93 for 3D macula, 3D optic disc, radial, and line scans, respectively. ICCs for retinal thickness increased to 0.88, 0.83, 0.89, and 0.76, respectively.
Conclusions: Improved repeatability of automated choroidal and retinal thickness measurements was found with the SS OCT after correction of scan artifacts. Recognition of scan artifacts is important for correct interpretation of SS OCT measurements.

Significance: Automated segmentation software in SS-OCT prototype (Topcon) provides highly repeatable measurements, however the repeatability may be affected by the presence of artefacts. Segmentation algorithms have since been updated and artifacts corrected, further improving the identification of tissue boundaries required for thickness measurements.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414000713

Zhang L, Buitendijk GH, Lee K, Sonka M, Springelkamp H, Hofman A, et al. Validity of Automated Choroidal Segmentation in SS-OCT and SD-OCT. Investigative Ophthalmology and Vision Science. 2015 May 1;56(5):3202-11.

Purpose: To evaluate the validity of a novel fully automated three-dimensional (3D) method capable of segmenting the choroid from two different optical coherence tomography scanners: swept-source OCT (SS-OCT) and spectral-domain OCT (SD-OCT).

Methods: One hundred eight subjects were imaged using SS-OCT and SD-OCT. A 3D method was used to segment the choroid and quantify the choroidal thickness along each A-scan. The segmented choroidal posterior boundary was evaluated by comparing to manual segmentation. Differences were assessed to test the agreement between segmentation results of the same subject. Choroidal thickness was defined as the Euclidian distance between Bruch's membrane and the choroidal posterior boundary, and reproducibility was analyzed using automatically and manually determined choroidal thicknesses.

Results: For SS-OCT, the average choroidal thickness of the entire 6- by 6-mm^2 macular region was 219.5 µm (95% confidence interval [CI], 204.9-234.2 µm), and for SD-OCT it was 209.5 µm (95% CI, 197.9-221.0 µm). The agreement between automated and manual segmentations was high: Average relative difference was less than 5 µm, and average absolute difference was less than 15 µm. Reproducibility of choroidal thickness between repeated SS-OCT scans was high (coefficient of variation [CV] of 3.3%, intraclass correlation coefficient [ICC] of 0.98), and differences between SS-OCT and SD-OCT results were small (CV of 11.0%, ICC of 0.73).

Conclusions: We have developed a fully automated 3D method for segmenting the choroid and quantifying choroidal thickness along each A-scan. The method yielded high validity. Our method can be used reliably to study local choroidal changes and may improve the diagnosis and management of patients with ocular diseases in which the choroid is affected.

Significance: This study reports the development of an automated method able to segment the choroid and determine its thickness from OCT images. The SS-OCT (DRI OCT-1 Atlantis) scans provide more reliable measurements due the better visibility of choroidal structures compared to SD-OCT.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2296463

Swept Source Optical Coherence Tomography –

Imaging of Pathological Features

Maruko I, Iida T, Sugano Y, Oyamada H, Sekiryu T. Morphologic choroidal and scleral changes at the macula in tilted disc syndrome with staphyloma using optical coherence tomography. Investigative Ophthalmology and Vision Science. 2011;52(12):8763-8.

Purpose: To evaluate the macular choroidal and scleral changes in tilted disc syndrome (TDS) with staphyloma using optical coherence tomography (OCT) to determine the mechanism of serous retinal detachment (SRD) formation.
Methods: All eyes underwent fluorescein (FA) and indocyanine green angiography (ICGA) in this retrospective, observational study. Enhanced-depth imaging (EDI) OCT and prototype high-penetration (HP) OCT were used to examine the choroid and sclera, respectively, at the upper and lower optical areas and the subfovea on vertical OCT sections.
Results: Twenty-four eyes with TDS with inferior staphyloma were included. FA showed the macular area with the superior edge of staphyloma had a granular hyperfluorescent pattern and ICGA showed belt-like hypofluorescence. OCT showed SRDs in seven eyes. The mean EDI-OCT choroidal thicknesses in 19 eyes were: upper area, 211 ± 79 µm; subfovea, 153 ± 70 µm; and lower area, 158 ± 42 µm. The mean subfoveal and lower choroid were significantly ($P < 0.01$ for both) thinner than the upper area. The mean HP-OCT scleral thicknesses in 14 eyes were: upper area, 414 ± 36 µm; subfovea, 493 ± 40 µm; and lower area, 398 ± 83 µm. The subfoveal sclera was significantly ($P < 0.01$) thicker than the others.
Conclusions: The subfoveal choroid was relatively thin and the subfoveal sclera thickened in TDS with a staphyloma edge at the macula. The area with retinal pigment epithelial (RPE) atrophy was hyperfluorescent on FA; choriocapillaris occlusion was hypofluorescent on ICGA. Characteristic anatomic subfoveal scleral alterations might lead to a thinner choroid and inhibit chorioscleral outflow; a secondary RPE disorder subsequently could cause SRDs.

Significance: The SS-OCT prototype (Topcon) and SD-OCT with enhanced depth imaging are comparable for measuring the choroid thickness, but the SS-OCT provides superior chorio-scleral interface visibility because of its greater tissue penetration.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2187037

Tsuchiya K, Moriyama M, Akiba M, Tamura Y, Ohno-Matsui K. Development of peripapillary venous loop in an eye with a small optic disc. International Ophthalmology. 2012 Apr;32(2):171-5.

Summary: Venous loops in the retina usually develop in association with obstructive vascular diseases such as retinal vein occlusion and also in eyes with optic nerve tumors that affect the blood flow. We present our findings in a myopic patient with small optic discs who developed a peripapillary venous loop in one eye without any obvious cause. We investigated the eye by swept-source optical coherence tomography (swept source OCT), and our findings provided evidence for a possible cause of the venous loop in this eye.

Significance: This case report demonstrates the ability of SS-OCT prototype to provide a clear, detailed image through the optic nerve head.

Link: http://link.springer.com/article/10.1007%2Fs10792-012-9529-1

Ellabban AA, Tsujikawa A, Ooto S, Yamashiro K, Oishi A, Nakata I, et al. Focal choroidal excavation in eyes with central serous chorioretinopathy. American Journal of Ophthalmology. 2013 Oct;156(4):673-83.

Purpose: To study the prevalence and 3-dimensional (3-D) tomographic features of focal choroidal excavations in eyes with central serous chorioretinopathy (CSC) using swept-source optical coherence tomography (OCT).
Design: Prospective, cross-sectional study.
Methods: We examined 116 consecutive eyes with CSC with a prototype 3-D swept-source OCT. 3-D images of the shape of the macular area, covering 6 × 6 mm(2), were reconstructed by segmentation of the outer surface of the retinal pigment epithelium (RPE).
Results: The 3-D swept-source OCT detected focal choroidal excavations in 9 eyes (7.8%). The 3-D scanning protocol, coupled with en face scans, allowed for clear visualization of the excavation morphology. In 5 eyes with focal excavations, unusual choroidal tissue was found beneath the excavation, bridging the bottom of the excavation and the outer choroidal boundary. Additionally, 3 of those 5 eyes showed a suprachoroidal space below the excavation, as if the outer choroidal boundary is pulled inward by this bridging tissue. The focal choroidal excavations were located within fluorescein leakage points and areas of choroidal hyperpermeability. Eyes with focal choroidal excavations were more myopic (-4.42 ± 2.92 diopters) than eyes without excavations (-0.27 ± 1.80 diopters, P = .001). Subfoveal choroidal thickness was significantly thinner (301.3 ± 60.1 µm) in eyes with focal excavations than in eyes without the excavations (376.6 ± 104.8 µm, P = .036).
Conclusions: Focal choroidal excavations were present in 7.8% of eyes with CSC. In these eyes, focal choroidal excavations may have formed from RPE retraction caused by focal scarring of choroidal connective tissue.

Significance: This study uses the lower signal decay with depth of the SS-OCT (Topcon) to improve the visibility of the choroid, allowing the identification of fine choroidal features that appear to be associated with CSC.

Link: http://www.sciencedirect.com/science/article/pii/S0002939413003280

Katome T, Mitamura Y, Hotta F, Mino A, Naito T. Swept-source optical coherence tomography identifies connection between vitreous cavity and retrobulbar subarachnoid space in patient with optic disc pit. Eye (London). 2013 Nov;27(11):1325-6.

Summary: Swept-source optical coherence tomography (SS-OCT) uses a wavelength swept laser as the light source, and it has less roll-off in sensitivity with increasing depth than spectral-domain OCT. In addition, SS-OCT instruments use a longer centre wavelength, which improved their ability to penetrate deeper into ocular tissues. Thus, evaluations of the deeper structures of the eye are possible. Herein, we report a case of optic disc pit (ODP) in whom a connection between the vitreous cavity and the retrobulbar subarachnoid space (SAS) was clearly demonstrated using SS-OCT.

Significance: This case report uses the longer window scan depth of the Swept Source DRI OCT-1 Atlantis to image critical vitreous detail, without compromising visibility of deeper structural features. A connection between the vitreous cavity and subarachnoid space is identified with implications for the clinical management of the condition.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3831131/

Ohno-Matsui K, Hirakata A, Inoue M, Akiba M, Ishibashi T. Evaluation of congenital optic disc pits and optic disc colobomas by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2013 Nov;54(12):7769-78.

Purpose: To investigate the structural abnormalities of optic disc pits and colobomas by swept-source optical coherence tomography (OCT).
Methods: Sixteen eyes with congenital optic disc pits, and seven eyes with optic disc colobomas were studied. Papillary and peripapillary areas were examined with swept-source OCT. The entire course of the pit or cavity and the spatial relationship between pits and retrobulbar subarachnoid space (SAS) were examined.
Results: Optical coherence tomography images showed the entire course of the pits from their openings to the bottom in 12 eyes. Shape of optic disc pits varied from sharp triangular cavities to longitudinally oval according to the depth of the pits. In the other four eyes, the pit narrowed into a tunnel along the optic nerve. The entire area of the optic disc was observed in three of seven eyes with disc coloboma by OCT. In all of the eyes with optic disc pits, the lamina cribrosa was torn off from the peripapillary sclera at the site of the pits. In two cases with optic disc pits and one case with optic disc coloboma, optical coherence tomography showed SAS immediately posterior to the highly reflective tissue lining the bottom of the excavation. The distance between the intraocular cavity and SAS in these three cases were 88, 126, and 133 µm.
Conclusions: Swept-source OCT is able to detect different kinds of abnormalities including shape of cavities, defect of lamina cribrosa, or distance to SAS in the excavated optic discs anomalies.

Significance: This study shows the capacity of SS-OCT prototype (Topcon) in imaging the full course of optic nerve pits.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2128089

Shinohara K, Moriyama M, Shimada N, Nagaoka N, Ishibashi T, Tokoro T, et al. Analyses of shape of eyes and structure of optic nerves in eyes with tilted disc syndrome by swept-source optical coherence tomography and three-dimensional magnetic resonance imaging. Eye (London). 2013 Nov;27(11):1233-41; quiz 42.

Purpose: To evaluate the deeper structures of the optic nerve and to analyze the shape of eyes with tilted disc syndrome (TDS) by swept-source optical coherence tomography (OCT) and three-dimensional magnetic resonance imaging (3D MRI).
Methods: The medical records of 54 eyes of 36 patients with TDS were reviewed. The patients with TDS and high myopia were analyzed separately from those without high myopia. All the eyes were examined with a swept-source OCT, and 22 of the eyes were examined by 3D MRI.
Results: A total of 38 eyes of 29 patients were highly myopic and 16 eyes of 15 patients were not highly myopic. The representative OCT findings of the optic disc were: a sloping of the lamina cribrosa posteriorly from the upper part to the lower part, a protrusion of the upper edge of Bruch's membrane, and choroid. The distance and the depth of the most protruded point from the fovea were significantly greater in the eyes with non-highly myopic TDS than those with highly myopic TDS. In the 3D MRI, the lower part of the posterior segment was protruded outward, and the optic nerves attached at the upper nasal edge of the protrusion.
Conclusions: The abnormalities detected by swept-source OCT and 3D MRI analyses indicate the possibility that the essential pathology of TDS is a deformity of the inferior globe below the optic nerve, and the positional relation between the fovea and the inferior protrusion determines the degree of myopia.

Significance: The SS-OCT prototype (Topcon) can clearly show the various abnormalities, including deep abnormalities, in the optic nerve and surrounding structures in the eyes with TDS.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3831145/

Hosoda Y, Uji A, Hangai M, Morooka S, Nishijima K, Yoshimura N. Relationship between retinal lesions and inward choroidal bulging in Vogt-Koyanagi-Harada disease. American Journal of Ophthalmology. 2014 May;157(5):1056-63.

Purpose: To investigate the correlation between choroidal and retinal lesions in eyes with acute Vogt-Koyanagi-Harada disease (VKH) using optical coherence tomography (OCT) by using a new parameter, retinal pigment epithelium (RPE) undulation index, which quantitatively describes choroidaldeformations.
Design: Retrospective, observational, cross-sectional study.
Methods: Spectral-domain OCT (SD OCT) and swept-source OCT images from a consecutive series of 42 eyes in 22 patients with acute VKH who underwent steroid therapy and 20 healthy eyes in 20 volunteers were analyzed retrospectively. Correlations between best-corrected visual acuity (BCVA), axial length change, and OCT parameters were examined. The RPE undulation index was defined as RPE line length to the total scan length ratio on a foveal-centered scan in the SD OCT image.
Results: Eyes with acute VKH showed increased RPE undulation index, choroidal thickness, and retinal thickness compared to normal subjects, which were reduced following steroidal treatment ($P < .0001$, $P = .0003$, and $P < .0001$, respectively). RPE undulation index was related to choroidal thickness ($r = 0.624$, $P = .0043$), retinal thickness ($r = 0.483$, $P = .0028$), and BCVA ($r = 0.588$, $P = .0002$). Meanwhile, no statistically significant relationship was observed between choroidal thickness and retinal thickness. Axial length changes were significantly correlated with both choroidal thickness ($r = 0.842$, $P < .0001$) and RPE undulation index ($r = 0.600$, $P = .0139$).
Conclusion: This study demonstrated that the choroid was diffusely undulated and bulged inward in eyes with acute VKH. Correlations between RPE undulation index and choroid morphology, retinal thickness, and poor BCVA suggest that choroidal folding, quantified by RPE undulation index, is useful in assessing VKH disease severity.

Significance: The SS-OCT (Topcon) allows a clear visualization and measurement of the choroid enabling determination of the effect of treatment for choroidal pathologies.

Link: http://www.ajo.com/article/S0002-9394(14)00045-2/abstract

Nagasawa T, Mitamura Y, Katome T, Nagasato D, Tabuchi H. Swept-source optical coherence tomographic findings in morning glory syndrome. Retina. 2014 Jan;34(1):206-8.

Summary: Swept-source optical coherence tomography (SSOCT) uses a wavelength swept laser as the light source. Swept-source optical coherence tomography can achieve much less roll-off in sensitivity with depth compared with spectral-domain optical coherence tomography. In addition, current SS-OCT device uses a longer center wavelength (1050 nm). Thus, evaluations of posterior structures are possible using SSOCT. We describe a patient with morning glory syndrome in whom the etrobulbar subarachnoid space (SAS) around optic nerve was clearly delineated using SS-OCT. The 68-year-old woman with morning glory syndrome and retinal detachment underwent vitrectomy. After surgery, SS-OCT (DRI OCT-1; Topcon, Tokyo, Japan) clearly delineated suspected SAS and its direct communication with the vitreous cavity.

Significance: The DRI OCT-1 Atlantis clearly delineates the entire features of subarachnoid space, despite the significant depth of this structure.

Link:
http://journals.lww.com/retinajournal/Citation/2014/01000/Swept_Source_Optical_Coherence_Tomographic.30.aspx

Dolz-Marco R, Rodriguez-Raton A, Hernandez-Martinez P, Pascual-Camps I, Andreu-Fenoll M, Gallego-Pinazo R. Macular retinal and choroidal thickness in unilateral relentless placoid chorioretinitis analyzed by swept-source optical coherence tomography. Journal of Ophthalmic Inflammation and Infection. 2014;4:24.

Background: The purpose of this study is to evaluate the retinal and choroidal thickness of the macular region in patients with unilateral relentless placoid chorioretinitis (RPC) and macular involvement. Patients diagnosed with RPC affecting only one eye underwent a comprehensive ophthalmologic examination including best-corrected visual acuity (BCVA), axial length (AL) measurement, slit-lamp examination, and color fundus and autofluorescence photography. The macular region was scanned by swept-source optical coherence tomography in the 1,050-nm wavelength. Automated segmentations of the retina and the choroid were used to obtain the corresponding thickness values.

Results: A total number of three patients (two men and one woman; age range 17 to 62 years) were included. Eyes with clinically evident RPC had a mean AL of 24.62 ± 0.11 mm, whereas in the clinically healthy fellow eyes, the mean AL was 24.65 ± 0.03 ($p = 0.70$). The mean BCVA was 0.93 ± 0.16 in eyes with RPC, and 1.0 in all the fellow eyes ($p = 0.70$). Slit-lamp examination did not reveal any sign of vitreous inflammation in any cases. The mean macular retinal thickness was 288.10 ± 10.22 µm in eyes with RPC, and 300.30 ± 7.17 µm in the healthy fellow eyes ($p = 0.20$). The mean central choroidal thickness was 260.70 ± 140.60 µm in eyes with RPC, and 262.30 ± 123.10 µm in the fellow eyes ($p = 0.99$). The mean macular choroidal thickness was 248.60 ± 128.40 and 255.10 ± 123.60 µm, respectively ($p = 0.99$).

Conclusions: The pathogenesis of RPC remains unknown. No changes in the retinal and choroidal thickness were observed in the macular area of eyes diagnosed with RPC with macular involvement compared with the asymptomatic healthy fellow eyes. Further prospective studies are warranted in order to investigate the role of the choroid in cases of RPC.

Significance: This clinical case report using the DRI OCT-1 Atlantis reinforces the importance of choroid thickness measurement in assisting the differential diagnosis of particular ophthalmic conditions.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4182277/

Ellabban AA, Tsujikawa A, Muraoka Y, Yamashiro K, Oishi A, Ooto S, et al. Dome-shaped macular configuration: longitudinal changes in the sclera and choroid by swept-source optical coherence tomography over two years. American Journal of Ophthalmology. 2014 Nov;158(5):1062-70.

Purpose: To study longitudinal changes in the posterior pole in eyes with dome-shaped macular configuration within the staphyloma.
Design: Prospective, longitudinal study.
Methods: We prospectively examined the macular area in 35 eyes (26 patients) with dome-shaped macular configuration and high myopia (mean spherical equivalent, -14.83 ± 4.50 diopters) using swept-source optical coherence tomography. Scleral and choroidal thicknesses were measured at the fovea and at 4 parafoveal locations 2000 µm from the foveal center. Height of the macular bulge was measured as well.
Results: During the mean follow-up of 24.8 ± 2.5 months, the scleral thickness significantly decreased at the fovea from 496.1 ± 95.7 µm to 484.7 ± 96.2 µm ($P < .001$) and at all 4 parafoveal locations ($P < .001$, respectively). The scleral thinning was asymmetric, with an estimated decrease per year of 5.6 µm at the foveal center, 11.1 µm superiorly, 12.1 µm inferiorly, 10.4 µm temporally, and 5.8 µm nasally. The ocular concavities deepened over time, and mean macular bulge height increased from 136.5 ± 60.9 µm to 157.6 ± 67.0 µm ($P < .001$). The choroid within the staphyloma showed generalized thinning during follow-up. Mean choroidal thickness decreased significantly at the fovea from 28.3 ± 17.2 µm at baseline to 22.9 ± 17.2 µm ($P < .001$).
Conclusions: Progressive asymmetric scleral thinning occurred in the macular region of eyes with dome-shaped macular configuration. The scleral thinning was more pronounced in the parafoveal area than at the foveal center, resulting in an increase of the macular bulge height.

Significance: This long follow-up study using the DRI OCT-1 Atlantis allows for the characterization of the scleral and choroidal thickness across a wide area.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414004863

Kuroda Y, Tsujikawa A, Ooto S, Yamashiro K, Oishi A, Nakanishi H, et al. Association of focal choroidal excavation with age-related macular degeneration. Investigative Ophthalmology and Vision Science. 2014 Sep;55(9):6046-54.

Purpose: To study the prevalence, tomographic features, and clinical characteristics of focal choroidal excavation (FCE) in eyes with exudative age-related macular degeneration (AMD).
Methods: We examined 243 consecutive eyes with exudative AMD with a prototype swept-source optical coherence tomography (OCT) system. Three-dimensional images of the macular area, covering 6 × 6 mm^2, were reconstructed by segmentation of the outer surface of the retinal pigment epithelium.
Results: Three-dimensional swept-source OCT revealed 15 excavations in 12 eyes (4.9%); 10 had a single excavation and 2 had multiple excavations (2 and 3 excavations, respectively). In multiaveraged scans, unusual choroidal tissue was found beneath 5 excavations, bridging the excavation with the outer choroidal boundary. Additionally, the suprachoroidal space was observed beneath 7 excavations-the outer choroidal boundary appeared to be pulled inward by this bridging tissue. In 9 excavations, color fundus photographs showed pigmentary disturbance. Fourteen excavations (93.3%) were located within or adjacent to the choroidal neovascularization area. Compared with eyes without FCE, in eyes with FCE, the mean age was significantly higher (P = 0.040) and mean visual acuity was significantly better (P = 0.014). In addition, polypoidal lesions were observed in 8 of 12 eyes with FCE, but they appeared to have a limited effect on either the rate of FCE (P = 0.44) or the clinical characteristics of the eyes.
Conclusions: While FCE may be partially related to the choroidal neovascularization associated with exudative AMD, other factors may also influence this association.

Significance: The fast imaging speed of the SS-OCT prototype (Topcon) allows for a dense scanning enabling the 3D image reconstruction of the posterior pole. The reconstruction of the macular area was evaluated in eyes with age related macular degeneration.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2166758

Mukai R, Sato T, Kishi S. A hyporeflective space between hyperreflective materials in pigment epithelial detachment and Bruch's membrane in neovascular age-related macular degeneration. BMC Ophthalmology. 2014;14:159.

Background: The purpose of this study was to investigate the clinical characteristics of a hyporeflective space between hyperreflective materials in pigment epithelial detachment (PED) and Bruch's membrane in neovascular age-related macular degeneration (AMD) using spectral-domain optical coherence tomography (SD-OCT) or swept source optical coherence tomography (SS-OCT).
Methods: Among 223 patients with neovascular AMD, 227 eyes were studied retrospectively. Using SD-OCT or SS-OCT, we reviewed clinical characteristics of the space.
Results: Twenty-two (10%) of the 227 eyes showed a space between hyperreflective materials in PED and Bruch's membrane. In all spaces, fibrovascular changes of the choroidal neovascularization (CNV) membrane were seen on funduscopy, with OCT images showing the retinal pigment epithelium (RPE) above the space adhering tightly and continuously to the CNV membranes. Nineteen (86%) of the 22 eyes with this cleft also had serous retinal detachment or cystoid macular edema. Five eyes (23%) had an RPE tear during follow-up.
Conclusions: A hyporeflective space between hyperreflective materials in PED and Bruch's membrane sometimes appears in neovascular AMD. The appearance of such a space may indicate residual activities of the hyperreflective materials.

Significance: Both the DRI OCT -1 Atlantis (swept source) and SD-OCT with enhanced depth imaging were able to image the retinal space between the RPE and Bruch’s membrane, although no direct comparison of imaging techniques was undertaken as part of this study.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4274686/

Ohsugi H, Ikuno Y, Oshima K, Yamauchi T, Tabuchi H. Morphologic characteristics of macular complications of a dome-shaped macula determined by swept-source optical coherence tomography. American Journal of Ophthalmology. 2014 Jul;158(1):162-70 e1.

Purpose: To investigate the morphologic characteristics of macular complications of dome-shaped maculas using swept-source optical coherence tomography (OCT).
Design: Retrospective observational case series.
Methods: Axial length measurements and swept-source OCT were performed in 49 highly myopic eyes (in 5 male and 30 female subjects) with dome-shaped maculas. We classified the dome patterns and measured the central retinal thickness, central choroidal thickness, central scleral thickness, and the macular bulge height, and assessed the associations of these parameters with macular complications.
Results: The central scleral thickness was significantly negatively correlated with age and the axial length. We classified the eyes into 3 groups: 6 with choroidal neovascularization (CNV group), 8 with retinal pigment epithelial detachment (PED group; 5 with serous retinal detachment), and 35 with no complications (no complications group). Nine eyes had a round dome and 40 had horizontally oriented oval-shaped domes. There were no significant differences in the frequency of macular complications between these patterns. The CNV group was significantly older and had a longer axial length than the other groups. The PED group had significantly larger values for both the central scleral thickness and bulge height than the other groups. The central choroidal thickness was significantly thinner in the CNV group than in the no complications group.
Conclusion: A dome-shaped macula results from relative thickening of the macular sclera, and this may lead to PED. Thinning of the sclera owing to long-term changes and elongation of the axis may develop CNV and cause visual impairment.

Significance: The DRI OCT-1 Atlantis allows the visualization of the outer scleral border systematically, leading of higher accuracy in the data when analysis of this structure is important.

Link: http://www.ajo.com/article/S0002-9394(14)00138-X/abstract

Flores-Moreno I, Arias-Barquet L, Rubio-Caso MJ, Ruiz-Moreno JM, Duker JS, Caminal JM. En face swept-source optical coherence tomography in neovascular age-related macular degeneration. British Journal of Ophthalmology. 2015 Feb 26.

Purpose: To describe en face swept-source optical coherence tomography (SS-OCT) findings in the retinal pigment epithelium (RPE) and choroid and to correlate them with fluorescein angiography (FA) and/or indocyanine green angiography (ICGA) in neovascular age-related macular degeneration (AMD).
Methods: Thirty-eight eyes with the recent diagnosis of neovascular AMD were imaged using an SS-OCT system. En face images were obtained at RPE, choriocapillaris, Sattler's layer and Haller's layer level. Analysis of the images and correlation with colour fundus photographs, FA, ICGA in selected cases, were made.
Results: En face images at RPE level revealed changes in all eyes. The neovascular complex appeared hyper-reflective in 9 of 38 eyes (23.7%), and in 29 of 38 eyes (76.3%), it was hyporeflective. The choriocapillaris en face image showed pathological changes in all eyes as well, and in 20 out of 38 eyes (52.6%), the alterations were hyper-reflective, while 18 of 38 eyes (47.4%) showed hyporeflective changes. Twenty (52.6%) eyes and 19 (50.0%) had a hyper-reflective lesion in Sattler's layer and Haller's layer, respectively, and 15 (39.4%) cases showed a hyporeflective lesion in both layers. No differences were found between the neovascular complex area, horizontal and vertical diameters, measured in the en face image and FA (p=0.171, p=0.061, p=0.133, respectively). Hyporeflective changes were predominant at RPE level and hyper-reflective at choriocapillaris, Sattler's and Haller's layers.
Conclusions: En face SS-OCT is a rapid, non-invasive, high-resolution, promising technology, which allows a complementary study to angiography of neovascular AMD. There is a correlation between angiography and en face SS-OCT images in neovascular AMD.

Significance: This study uses new software on the DRI OCT-1 Atlantis to generate high resolution en face images, including deep within the choroid, enabled by the long wavelength of light and the limited drop off of signal to noise ratio associated with swept source technology. The en face images provide valuable information using non-invasive methods and compare well with fluorescein angiography images.

Link: http://bjo.bmj.com/content/early/2015/02/26/bjophthalmol-2014-306422.long

Flores-Moreno I, Caminal JM, Arias-Barquet L, Rubio-Caso MJ, Catala-Mora J, Vidal-Marti M, et al. En face mode of swept-source optical coherence tomography in circumscribed choroidal haemangioma. British Journal of Ophthalmology. 2015 Jul 23.

Purpose: To describe the findings in circumscribed choroidal haemangioma (CCH) using en face swept-source optical coherence tomography (SS-OCT).
Methods: En face images were obtained employing DRI-1 Atlantis OCT (Topcon, Tokyo, Japan), using a three-dimensional volumetric scan of 12x9 mm. Images were obtained from the retinal pigment epithelium to 1000 mum in depth of the tumour.
Results: Twenty-two eyes from 22 patients with the clinical diagnosis of CCH were included. In 20 eyes (90.9%), a characteristic pattern was visualised in the en face image across the vascular tumour. A multilobular pattern, similar to a honeycomb, with hyporeflective, confluent, oval or round areas corresponding with the lumen of the tumour vascular spaces, and hyper-reflective zones, which may represent the vessels walls and connective tissue of the tumour. Ten eyes (45.4%) showed a hyper-reflective halo surrounding the tumour. Seventeen tumours (77.2%) showed small diameter vessels at the inner zone and larger vessels in the outer area. Twelve patients (54.5%) had previously received treatment (photodynamic therapy, transpupillary thermotherapy, dexamethasone intravitreal implant or brachytherapy with ruthenium-106). No differences were found between treated and untreated patients in any of the measured parameters.
Conclusions: En face SS-OCT is a rapid, non-invasive, high-resolution technology, which allows complementary study to cross-sectional scans in CCH. A characteristic multilobular pattern, with a hyper-reflective halo surrounding the tumour, was found in en face SS-OCT images. No morphological differences were found between naive patients and patients who received previous treatment.

Significance: En face mode imaging on the DRI-1 Atlantis OCT enables a coronal view of deep posterior segment structures at varying depth levels, complementing the information provided by cross-sectional scans. The long 1µm wavelength of the Topcon swept source instrument enables penetration of vascular structures within the tumour, and hence the ability to capture structural information from beneath the vessels.

Link: http://bjo.bmj.com/content/early/2015/07/23/bjophthalmol-2015-307099.long

Michalewska Z, Michalewski J, Nawrocka Z, Dulczewska-Cichecka K, Nawrocki J. The outer choroidoscleral boundary in full-thickness macular holes before and after surgery a swept-source OCT study. Graefe's Archives for Clinical and Experimental Ophthalmology. 2015 Feb 5.

Purpose: To report on choroidal thickness and the morphology of the outer choroidoscleral boundary in swept-source OCT in patients with full-thickness macular holes (FTMH) before and after surgery.
Methods: Single center matched case-control study of 32 patients with FTMH (group 1), fellow eyes (group 2), and 32 eyes of 32 healthy controls (group 3). All eyes from group 1 had vitrectomy with a minimum follow-up of 3 months. Main outcome measures were the visibility and regularity of the outer choroidoscleral boundary (CSB), and additionally the eventual visibility of the suprachoroidal layer (SCL).
Results: Choroidal thickness was indifferent between groups. Choroidal thickness did not change after surgery ($p = 0.1$). CSB was visible in all cases. CSB was irregular in 59 % of eyes in group 1, in 40 % of eyes in group 2, and in any eye in group 3. SCL was visible in 34 % of eyes in group 1, and remained visible after surgery. In group 2, SCL was observed in 44 % of eyes, and in group 3 in one eye.
Conclusions: Choroidal thickness does not differ between eyes with FTMH and their fellow eyes and healthy controls. CSB is more often irregular and SCL is more often visible in eyes with FTMH and their fellow eyes than in healthy controls. In fellow eyes of FTMH, the visibility of SCL was observed more often in eyes with partial vitreous detachment ($p = 0.0$). Three months after surgery, choroidal thickness does not change, the irregularities of CSB and SCL remain visible. More frequent changes of the outer choroidoscleral boundary in FTMH, and especially in their fellow eyes, may suggest a role of the choroid in the pathogenesis of FTMH.

Significance: The high penetration of swept source DRI OCT-1 Atlantis allows an accurate inter-eye comparison of choroid thickness because of its deep penetration, revealing a new line of enquiry for the possible pathogenesis of FTMH.

Link: http://link.springer.com/article/10.1007%2Fs00417-015-2937-y

Papavasileiou E, Miller JB, Sobrin L. Swept-source optical coherence tomography findings in convalescent phase of treated sarcoid choroidal granulomas. Retinal Cases & Brief Reports. 2015 May 29.

Purpose: To report swept-source optical coherence tomography findings of sarcoid choroidal granulomas in the post-treatment convalescent stage of disease.
Patients/Methods: The authors retrospectively reviewed charts from patients with sarcoid-related choroidal granulomas and recorded pertinent examination and imaging findings. Swept-source optical coherence tomography was performed using the DRI 3D-OCT-1 Atlantis (Topcon) over the areas of previous choroidal granulomas after the patients had been treated.
Results: Three patients with sarcoid choroidal granulomas were imaged with swept-source optical coherence tomography. Findings included loss or alteration of choroidal architecture, subretinal fibrosis, and outer retinal tubulations in the areas of the sarcoid granulomas after treatment. In one case with an associated choroidal neovascular membrane, there was also disruption of Bruch membrane and loss of normal choroidal vascular network in the area of the lesion.
Conclusion: Swept-source optical coherence tomography demonstrated significant anatomical sequelae that persisted after treatment of sarcoid granulomas. To the best of the authors' knowledge, this is the first report of outer retinal tubulations over healed sarcoid granulomas.

Significance: Swept source OCT was able to provide clear images of modified choroidal features as a result of previous granulomas.

Link:
http://journals.lww.com/retinalcases/pages/articleviewer.aspx?year=9000&issue=00000&article=99405&type=abstract

Tanawade RG, Muqit MM, McLeod D, Stanga PE. Swept-source optical coherence tomography imaging in conservative and surgical management of premacular haemorrhages showing inflammatory response. Clinical and Experimental Ophthalmology. 2015 Jan-Feb;43(1):77-9.

Premacular haemorrhages occur in a variety of conditions. A haemorrhage in a subinternal limiting membrane (ILM) location typically results from acute hyperelevation of the intravascular (or 'lateral') pressure within the retinal veins, which then 'blow out' like a punctured tyre. Knowing whether a haemorrhage is sub-hyaloid or sub-ILM, and whether or not there is an inflammatory component, may be important in planning management.
Swept-Source Deep Range Imaging Optical Coherence Tomography (DRI-OCT1 Atlantis, Topcon Corp., Tokyo, Japan) is a new imaging technology that operates at a speed of 100 000 A-scans/s using a wavelength of 1050 nm. This is the first report of the use of swept-source (SS-OCT) in premacular haemorrhages to determine not only their anatomical location, but also to show an intraoperative correlation, demonstrate spontaneous resolution of sub-ILM pockets and show a likely inflammatory component to the disease.

Significance: This study demonstrates the usefulness of DRI OCT-1 Atlantis in assessing the precise anatomical location of, and in facilitating clinical management of premacular haemorrhages.

Link: http://onlinelibrary.wiley.com/doi/10.1111/ceo.12368/abstract

Dansingani KK, Naysan J, Freund KB. Silicone Oil Confined Within a Lamellar Macular Hole as Demonstrated by En Face Swept Source Optical Coherence Tomography. JAMA Ophthalmology. 2015 Jul;133(7):e15112.

Summary: A man in his early 60s with pathologic myopia had undergone multiple procedures, including vitrectomy and cataract surgery, on the left eye for a rhegmatogenous retinal detachment 2 years previously. He subsequently had received multiple intravitreous ranibizumab injections to the left eye for myopic choroidal neovascularization. Best-corrected visual acuities were 20/40 OD and 20/200 OS.

Multimodal imaging revealed emulsified silicone oil forming a meniscus in the fovea of the left eye. En face imaging with swept source optical coherence tomography demonstrated the confinement of the hyperoleon within a lamellar macular hole.

Significance: the long wavelength of swept source OCT enabled imaging of the macula through media opacification associated with the presence of emulsified silicone oil.

Link: http://archopht.jamanetwork.com/article.aspx?articleid=2343072

Dansingani KK, Balaratnasingam C, Naysan J, Freund KB. En face imaging of pachychoroid spectrum disorders with swept-source optical coherence tomography. Retina. 2015 Aug 12.

Purpose: To correlate clinical manifestations with choroidal morphology in pachychoroid disorders, including central serous chorioretinopathy, pachychoroid pigment epitheliopathy, pachychoroid neovasculopathy, and polypoidal choroidal vasculopathy, using en face swept-source optical coherence tomography (OCT).
Methods: Patients with pachychoroid spectrum diagnoses were identified nonconsecutively through a review of charts and multimodal imaging. Each eye was categorized as uncomplicated pachychoroid, pachychoroid pigment epitheliopathy, central serous chorioretinopathy, pachychoroid neovasculopathy, or polypoidal choroidal vasculopathy. All patients included in this series then underwent bilateral swept-source OCT.
Results: Sixty-six eyes of 33 patients were included. Numbers assigned to diagnostic categories were 8 uncomplicatedpachychoroid, 13 pachychoroid pigment epitheliopathy, 27 central serous chorioretinopathy, 15 pachychoroidneovasculopathy, and 3 polypoidal choroidal vasculopathy. One eye was classified as normal. Swept-source OCT choroidal thickness maps confirmed increased thickness under the areas of pachychoroid pigment epitheliopathy, central serous chorioretinopathy, type 1 NV (pachychoroid neovasculopathy), or polyps (polypoidal choroidal vasculopathy). En face swept-source OCT showed dilated outer choroidal vessels in all eyes. In several eyes with a chronic disease, focal choriocapillaris atrophy with inward displacement of deep choroidal vessels was noted.
Conclusion: Although clinical manifestations of pachychoroid spectrum disorders vary considerably, these entities share morphologic findings in the choroid, including increased thickness and dilated outer choroidal vessels. En face swept-source OCT localizes these changes to disease foci and shows additional findings that may unify our understanding of disease pathogenesis.

Significance: The deep penetration of en face SS-OCT (DRI OCT-1 Atlantis) enabled by the 1µm light source and robust signal to noise ratio with depth, exposes choroidal morphology in a way not previously possible and enables subsegmentation of the choroid to be performed on the basis of transitions in morphology with increasing depth.

Link:
http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=9000&issue=00000&article=97862&type=abstract

Wang J, Gao X, Huang W, Wang W, Chen S, Du S, et al. Swept-source optical coherence tomography imaging of macular retinal and choroidal structures in healthy eyes. BMC Ophthalmology. 2015;15(1):122.

Background: To report the thickness of the retina, retinal ganglion cell (RGC)-related layers, and choroid in healthysubjects using swept source optical coherence tomography (SS-OCT).
Methods: One hundred and forty-six healthy volunteers were consecutively recruited for this prospective observational study. Thickness of retina, RGC-related layers, and choroid in the standard early treatment of diabetic retinopathy study (ETDRS) grid were automatically measured using one SS-OCT (DRI OCT-1, Topcon, Japan). The IOL Master (Carl Zeiss Meditec, Germany) was used to measure axial length (AL).
Results: Thicknesses of the average macular ganglion cell complex (GCC) and ganglion cell-inner plexiform layer (GCIPL) were 105.3 ± 9.7 and 78.5 ± 6.2 um respectively. Neither of them was significantly related with sex, age, or AL. Both showed strong correlations with retinal thickness ($r = 0.793$, $p = 0.000$; $r = 0.813$, $p = 0.000$, respectively) and with similar topographic distributions within the retina. The thicknesses of retina and GCC/GCIPL in the inner sectors were significantly higher than in the outer sectors of the EDTRS area, while in the same region of the macula, the choroid exhibited completely different patterns of topographic variation. Men had 7.8 um thicker retina and 34.9 um thicker choroid than women after adjustment for age and AL (all $p < 0.05$). Age and AL could significantly influence the choroidal thickness but not the retina (all $p < 0.05$).
Conclusion: Thickness of GCC/GCIPL in healthy Chinese individuals is not dramatically different across gender, age, and AL groups in terms of ETDRS grid, but sex is critical for retinal and choroidal thickness. Choroidal structure (but not retinal) can be significantly influenced by age and AL.

Significance: DRI OCT-1 Atlantis enables the automatic and systematic detection of the internal retinal structures and measurements of choroidal thickness, revealing subtle differences with age and axial length.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4574621/

Sakimoto S, Gomi F, Sakaguchi H, Akiba M, Kamei M, Nishida K. Analysis of retinal nonperfusion using depth-integrated optical coherence tomography images in eyes with branch retinal vein occlusion. Investigative Ophthalmology and Vision Science. 2015 Jan;56(1):640-6.

Purpose: To assess the morphology of areas of complete retinal nonperfusion in eyes with branch retinal vein occlusion (BRVO) by en face images of optical coherence tomography (OCT).
Methods: Forty-six eyes with BRVO that underwent swept-source OCT (SS-OCT) and fluorescein angiography were enrolled. Depth-integrated images of the neural retina delineated by automated segmentation algorithm were obtained using SS-OCT. The findings in a 6 × 6-mm area on en face SS-OCT scans at the area of retinal nonperfusion were evaluated.
Results: Retinal nonperfusion was detected in 25 eyes. Of these, 20 (80%) eyes had multiple concaves of low reflectivity within an area of reticular high reflectivity (honeycomb sign) on depth-integrated images at the area corresponding to retinal nonperfusion. The mean area of retinal nonperfusionand honeycomb sign were 6.72 ± 4.10 mm^2 and 4.19 ± 3.37 mm^2, respectively. The area of retinal nonperfusion was correlated significantly ($r = 0.53$, $P < 0.001$) with the area of the honeycomb sign. The mean retinal thickness in eyes with a honeycomb sign increased significantly ($P = 0.017$) compared with eyes without a honeycomb sign. Furthermore, after anti-VEGF injection, the mean area of honeycomb sign decreased significantly ($P = 0.0013$), from 4.23 mm^2 to 0.48 mm^2.
Conclusions: Depth-integrated OCT images with automated layer segmentation showed a two-dimensional honeycomb-like structure in retinal nonperfusion with retinal edema. In eyes with BRVO, the thickness of retina did not decrease but increased due to retinal cysts in spite of neural retinal thinning.

Significance: En face imaging of DRI-1 Atlantis OCT, provides useful coronal images of posterior structures. There was a strong correlation and colocalization between areas of non-perfusion as measured by FA, and honeycomb-like areas identified by SS OCT.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2212809

Swept Source Optical Coherence Tomography –

Choroid

Ikuno Y, Kawaguchi K, Nouchi T, Yasuno Y. Choroidal thickness in healthy Japanese subjects. Investigative Ophthalmology and Vision Science. 2010 Apr;51(4):2173-6.

Purpose: To study posterior choroidal thickness and its profile based on location in healthy Japanese subjects and the correlation with axial length, refractive error (RE), and age.
Methods: Eighty-six eyes of 43 healthy volunteers with no ophthalmic or systemic symptoms were examined with prototype high-penetration optical coherence tomography using a 1060-nm light source. Eyes with high myopia (exceeding -6 D) or with retinal/choroidal disease were excluded. The spherical equivalent RE was measured by autorefractometry, and the axial length was measured by partial coherence inferometry.
Results: Mean choroidal thicknesses were 354 +/- 111 mum at the fovea, 364 +/- 86 mum superiorly, 345 +/- 108 mum inferiorly, 227 +/- 532 mum nasally, and 337 +/- 102 mum temporally. Subfoveal choroidal thickness was significantly greater than nasal ($P < 0.01$) and temporal ($P < 0.05$) choroidal thickness; however, there was no significant difference compared with superior ($P = 0.20$) and inferior ($P = 0.17$) choroidal thickness. The temporal choroid was significantly ($P < 0.01$) thicker than the nasal choroid, and the inferior choroid was significantly ($P < 0.01$) thinner than the superior choroid. There was a significant negative correlation between foveal choroidal thickness and axial length ($P < 0.05$) but a borderline correlation with the RE ($P = 0.086$) and age ($P = 0.07$). Age was the factor that was most associated with the choroidal thickness ($F = 20.86$; $P < 0.001$), followed by RE ($F = 5.37$; $P < 0.05$); axial length was not a significant factor ($F = 1.47$; $P = 0.22$) by stepwise analysis.
Conclusions: The profile of choroidal thickness depends on its location. RE, axial length, and especially age are critical for evaluation of choroidal thickness.

Significance: The study demonstrates the applicability of SS-OCT for systematic choroid thickness measurement in the macular region.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2186229

Agawa T, Miura M, Ikuno Y, Makita S, Fabritius T, Iwasaki T, et al. Choroidal thickness measurement in healthy Japanese subjects by three-dimensional high-penetration optical coherence tomography. Graefe's Archives for Clinical and Experimental Ophthalmology. 2011 Oct;249(10):1485-92.

Background: We performed retinal and choroidal thickness mapping by three-dimensional high-penetration optical coherence tomography (OCT) and evaluated the choroidal thickness distribution throughout the macula in healthy eyes.
Methods: Forty-three eyes of 43 healthy Japanese volunteers were evaluated by 1060-nm swept-source OCT. The eyes were scanned with a three-dimensional raster scanning protocol, and the mean retinal and choroidal thicknesses of the posterior sectors were obtained. The sectors were defined by the Early Treatment Diabetic Study (ETDRS) layout. These data were compared by age (23-56 years), spherical equivalent refractive error (between +0.9 D and -10.3 D), and axial length (22.9-27.6 mm).
Results: The mean retinal and choroidal thicknesses of the ETDRS area were 284 ± 14 µm and 348 ± 63 µm respectively. The mean regional choroidal thicknesses in the nasal inner macula and nasal outer macula were significantly smaller than those in all other sectors. The mean regional choroidal thickness in most sectors showed a significant negative correlation with axial length and a significant positive correlation with refractive error. In eyes with a long axial length (>25.0 mm), the mean regional choroidal thickness of five sectors showed a significant negative correlation with age. The coefficient of variation of choroidal thickness between sectors showed a significant negative correlation with axial length, and a positive correlation with refractive error. The mean retinal thickness in each sector was not significantly correlated with the mean choroidal thickness, age, axial length, or refractive error.
Conclusions: The choroidal thickness map showed a distribution entirely different from the retinal thickness map. Choroidal thickness varies significantly with location, axial length, refractive error, and age. These variations should be considered when evaluating choroidal thickness.

Significance: SS-OCT allows detailed and rapid measurement of choroid thickness in a single measure, covering a wide macular region.

Link: http://link.springer.com/article/10.1007%2Fs00417-011-1708-7

Hirata M, Tsujikawa A, Matsumoto A, Hangai M, Ooto S, Yamashiro K, et al. Macular choroidal thickness and volume in normal subjects measured by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2011 Jul;52(8):4971-8.

Purpose: To study the choroidal thickness in healthy subjects by swept-source optical coherence tomography (SS-OCT) at longer wavelength.
Methods: The macular area of 31 eyes (31 healthy volunteers) was studied with an SS-OCT prototype system, which uses a tunable laser as a light source operated at 100,000 Hz A scan repetition rate in the 1-µm wavelength region. Three-dimensional volumetric measurement comprised of 512 × 128 A scans was acquired in 0.8 second. From a series of OCT images, a chroidal thickness map of the macular area was created by manual segmentation. To evaluate interoperator reproducibility, the choroidal thickness in each section from 10 subjects was determined independently by two observers.
Results: SS-OCT at the 1-µm wavelength region allowed visualization of the fine structure of the choroid as well as that of the retina. Mean choroidal thickness and volume in the macula area were, respectively, 191.5 ± 74.2 µm and 5.411 ± 2.097 mm(3). The mean choroidal thickness of the outer nasal area was significantly thinner than that of all other areas ($P < 0.05$). The measurements by the two independent observers were significantly identical; the intraclass correlation coefficient in mean choroidal thickness was between 0.945 and 0.980 in each area. The macular choroidal thickness was significantly correlated with axial length after adjustment for age ($P < 0.001$), and with age after adjustment for axial length ($P < 0.001$).
Conclusions: SS-OCT system at 1 µm provides macular choroidal thickness maps and allows one to evaluate the choroidal thickness more accurately.

Significance: The fast scanning of the SS-OCT prototype (Topcon) allows for multi-averaging of scans which enables the measurement of retina and choroid thickness in macular area in a single measure. Choroidal thickness was described using a ETDRS layout.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2187041

Usui S, Ikuno Y, Akiba M, Maruko I, Sekiryu T, Nishida K, et al. Circadian changes in subfoveal choroidal thickness and the relationship with circulatory factors in healthy subjects. Investigative Ophthalmology and Vision Science. 2012 Apr;53(4):2300-7.

Purpose: To investigate circadian changes in subfoveal choroidal thickness (SFCT) and the relation to systemic factors in healthy subjects.
Methods: Thirty-eight eyes of 19 healthy volunteers were enrolled. SFCT was measured by using prototype high-penetration optical coherence tomography. Intraocular pressure (IOP), systolic blood pressure (SBP), diastolic blood pressures (DBP), and heart rate (HR) were measured every 3 hours over a 24-hour period. Circadian changes in the mean arterial pressure (MAP) and mean ocular perfusion pressure (MOPP) were calculated. The difference between the maximal and minimal SFCTs was analyzed, and correlations between the SFCT and other systemic factors were evaluated.
Results: There was a significant circadian variation in SFCT ($P < 0.0001$). The total mean SFCT was 280.3 ± 106.1 µm. At 6 PM, the mean SFCT (271.9 ± 103.5 µm) was the thinnest and at 3 AM it was the thickest (290.8 ± 110.8 µm). The SFCTs in 32 of 38 eyes were thickest between 3 and 9 AM and in 27 of 38 eyes, thinnest between 3 and 9 PM. The mean SFCT was significantly negatively correlated with the mean SBP ($R(2) = 0.59$, $P = 0.02$) in all eyes. There were no significant correlations between the mean SFCT and the mean DBP, MAP, HR, IOP, and MOPP in all eyes.
Conclusions: We investigated the circadian change of choroidal thickness using high-penetration optical coherence tomography in healthy volunteers. The significant diurnal change was found and the choroid was thicker at night and thinner in daytime. Fluctuations in the choroidal thickness may be related to SBP.

Significance: The higher penetration of SS-OCT allows measurement of the full thickness of the choroid, enabling the detection of subtle changes in its thickness, such as those associated with the circadian cycle.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2188837

Ellabban AA, Tsujikawa A, Matsumoto A, Ogino K, Hangai M, Ooto S, et al. Macular choroidal thickness and volume in eyes with angioid streaks measured by swept source optical coherence tomography. American Journal of Ophthalmology. 2012 Jun;153(6):1133-43 e1.

Purpose: To study the mean choroidal thickness and volume of the macula in eyes with angioid streaks using swept source optical coherence tomography (OCT) in the 1050-nm wavelength range.
Design: Prospective case series.
Methods: The macular area of 39 eyes of 23 patients with angioid streaks and of 20 normal eyes of 20 matched controls (Group 1) was studied with a swept source OCT prototype system. Eyes with angioid streaks were classified into 1 of 4 groups: those without choroidal neovascularization (CNV) (Group 2); those with CNV that had no history of treatment (Group 3); those with CNV that had previously received only anti-vascular endothelial growth factor treatments (Group 4); and those with CNV that had previously received photodynamic therapy (Group 5). Using a raster scan protocol with 512 × 128 A-scans, we produced a macular choroidal thickness map (6 × 6 mm^2).
Results: There were no significant differences in age, axial length, or refractive error among the 5 groups. Mean choroidal thickness of the macula in Group 2 (218.9 ± 46.8 μm) was as great as that in Group 1 (218.8 ± 69.2 μm). However, the macular choroidal thickness in Group 3 (119.7 ± 49.2 μm), Group 4 (140.1 ± 64.9 μm), and Group 5 (144.0 ± 52.6 μm) was significantly less than that of Group 1 ($P < .05$). There were no statistical differences between Groups 3 through 5. In each group, the choroid of the nasal quadrant was significantly thinner compared to that in other quadrants ($P < .05$).
Conclusions: The choroid in eyes with angioid streaks without CNV was as thick as that in normal controls, but was significantly thinner in eyes with angioid streaks that had developed CNV.

Significance: The combination of high-speed scan, deep penetraion of the Topcon swept source OCT, and its multi-averaging of scans allows highly reproducible measurements of choroid thickness.

Link: http://www.sciencedirect.com/science/article/pii/S0002939412000037

Ellabban AA, Tsujikawa A, Matsumoto A, Yamashiro K, Oishi A, Ooto S, et al. Macular choroidal thickness measured by swept source optical coherence tomography in eyes with inferior posterior staphyloma. Investigative Ophthalmology and Vision Science. 2012 Nov;53(12):7735-45.

Purpose: To study the choroidal thickness in eyes with inferior posterior staphyloma (IPS) and to elucidate its role in the development of macular complications.
Methods: The macular area of 42 eyes of 32 patients with IPS was studied prospectively with swept source optical coherence tomography at 1050 nm. Using a raster scan protocol with 512 × 128 A-scans, we produced a macular choroidal thickness map (6 × 6-mm^2).
Results: Eyes with IPS showed relatively well-preserved choroid outside of the staphyloma but the inferior-nasal choroid within the staphyloma was thinned substantially. In addition, eyes with IPS often had a belt-shaped area with the thinnest choroid along the superior border of the staphyloma. As patient age increased, choroidal thinning progressed in the entire macular area. The macular choroidal thickness showed a close correlation with age (R^2 = 0.506, P < 0.001). On the superior border of the staphyloma, 13 eyes (30.9%) showed serous retinal detachment and/or pigment epithelial detachment without neovascularization, and eight (19.0%) showed neovascularization. Patients with neovascularization were older and had worse visual acuity (P < 0.001). Macular choroidal thickness in eyes with neovascular complications (76.5 ± 19.9 µm) was significantly reduced compared with that of eyes with no complication (133.0 ± 61.9 µm, P = 0.035).
Conclusions: Eyes with IPS showed marked choroidal thinning along the superior border of the staphyloma. Reduction of the choroidal thickness progressed with age and seemed to be involved in the development of neovascularization associated with the IPS.

Significance: This study uses the combination of better penetration due to a 1µm light source, the lower signal decay with depth and high speed scan associated with swept source, to produce large line scans, which allow the measurement of choroid or retinal thickness with an unprecedented dimension.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2127474

Ruiz-Moreno JM, Flores-Moreno I, Lugo F, Ruiz-Medrano J, Montero JA, Akiba M. Macular choroidal thickness in normal pediatric population measured by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2013 Jan;54(1):353-9.

Purpose: To evaluate choroidal thickness in healthy pediatric population by swept-source longer-wavelength optical coherence tomography (SS-OCT).
Methods: This was a cross-sectional comparative, noninterventional study. The macular area of 83 eyes from 43 pediatric patients (<18 years) was studied with an SS-OCT prototype system. Macular choroidal thickness was manually determined at 750-µm intervals by measuring the perpendicular distance from the posterior edge of the RPE to the choroid/sclera junction, along a horizontal 4500-µm line centered in the fovea. Three observers independently determined choroidal thickness. Pediatric choroidal thickness was compared with choroidal thickness from 75 eyes from 50 normal healthy adult volunteers (18 years or older).
Results: Mean age was 10 ± 3 years (3-17) in the pediatric population versus 53 ± 16 (25-85) in the adult population ($P < 0.001$). Mean spherical equivalent was not different ($P = 0.06$) between both groups. Mean subfoveal choroidal thickness was 312.9 ± 65.3 µm in the pediatric versus 305.6 ± 102.6 µm in the adult population ($P = 0.19$). Mean macular choroidal thickness was 285.2 ± 56.7 µm in the pediatric versus 275.2 ± 92.7 µm in the adult population ($P = 0.08$). The distribution of choroidal thickness along the horizontal line was different for both populations; the temporal choroid was thicker in the pediatric population (320, 322, and 324 µm; $P = 0.002$, 0.001, and 0.06, respectively), followed by the subfoveal (312 µm) and nasal choroid (281, 239, and 195 µm).
Conclusions: Macular choroidal thickness in the pediatric population is not significantly thicker than that of healthy adults. Differences are more remarkable in the temporal side of the fovea.

Significance: The SS-OCT prototype (Topcon) allows the systematic imaging of the choroidal borders, therefore allowing for good inter–operator choroid thickness measurement agreement.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2188846

Mansouri K, Medeiros FA, Marchase N, Tatham AJ, Auerbach D, Weinreb RN. Assessment of choroidal thickness and volume during the water drinking test by swept-source optical coherence tomography. Ophthalmology. 2013 Dec;120(12):2508-1.

Objective: To evaluate changes in peripapillary and macular choroidal thickness and volume after the water-drinking test (WDT) using swept-source optical coherence tomography (SS OCT).
Design: Prospective, cross-sectional, observational study.
Participants: Fifty-six eyes of 28 healthy volunteers.
Methods: Participants underwent a 3-dimensional optic disc and macula scanning protocol with a prototype SS OCT (Topcon, Inc., Tokyo, Japan) at baseline and 15, 30, 45, and 120 minutes after the start of the WDT. The WDT consisted of drinking 1000 ml of water within 5 minutes. Objective measurements of the choroid were obtained with automated segmentation of the choroidal boundaries.
Main Outcome Measures: Choroidal thickness and volume**.**
Results: Mean age ± standard deviation of participants was 35.6 ± 9.1 years. Intraocular pressure (IOP) increased from 14.9 ± 2.7 mmHg at baseline to a peak of 16.8 ± 3.0 mmHg 15 minutes after the WDT ($P < 0.001$). Mean baseline choroidal thickness and volume were 181.3 ± 50.8 µm and 6.19 ± 1.80 mm(3), respectively, at the optic disc and 217.4 ± 43.6 µm and 7.83 ± 1.55 mm(3), respectively, at the macula. After the WDT, peripapillary and macular choroidal thickness increased by a maximum of 5.7% ($P<0.001$) and 4.3% ($P<0.001$), respectively. Choroidal volumes increased by 6.4% ($P<0.001$) and 3.9% ($P<0.001$), respectively. There was no association between change in IOP and peripapillary ($P = 0.27$) or macular ($P = 0.09$) choroidal thickness.
Conclusions: Using automated segmentation of SS OCT measurements, significant increases in choroidal thickness and volume are observed after the WDT in healthy subjects.

Significance: Swept source OCT allows subtle changes in choroidal thickness as a result of water drinking to be mapped.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3833954/

Nagasawa T, Mitamura Y, Katome T, Shinomiya K, Naito T, Nagasato D, et al. Macular choroidal thickness and volume in healthy pediatric individuals measured by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2013;54(10):7068-74.

Purpose: We evaluated the choroidal thickness and volume in healthy pediatric individuals by swept-source optical coherence tomography (SS-OCT) and compared the findings to those of adults.
Methods: We examined 100 eyes of 100 healthy pediatric volunteers (3-15 years) and 83 eyes of 83 healthy adult volunteers (24-87 years) by SS-OCT with a tunable long wavelength laser source. The three-dimensional raster scan protocol was used to construct a choroidal thickness map. When the built-in software delineated an erroneous chorioscleral border in the B-scan images, manual segmentation was used.
Results: The central choroidal thickness and volume within a 1.0-mm circle were significantly larger in the children (260.4 ± 57.2 µm, 0.205 ± 0.045 mm(3)) than in the adults (206.1 ± 72.5 µm, 0.160 ± 0.056 mm(3), both $P < 0.0001$). In the children, the mean choroidal thickness of the nasal area was significantly thinner than that of all other areas ($P < 0.005$). Pediatric choroidal thinning with increasing age in the central area was faster than that in the outer areas. Stepwise regression analysis showed that the axial length and body mass index had the highest correlation with the choroidal thickness ($R(2) = 0.313$, $P < 0.0001$).
Conclusions: The macular choroidal thickness and volume in the pediatric individuals were significantly larger than those in the adults. The pediatric choroidal thinning with increasing age is more rapid in the central area. Pediatric choroidal thickness is associated with several systemic or ocular parameters, especially the axial length and body mass index. These differences should be remembered when the choroidal thickness is evaluated in pediatric patients with retinochoroidal diseases.

Significance: Application of a semiautomatic choroidal segmentation protocol provided by the DRI OCT-1 enables accurate and reproducible measurements of choroid thickness in a paediatric population, of relevance to the management of retinochoroidal disease.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2203067

Razavi S, Souied EH, Cavallero E, Weber M, Querques G. Assessment of choroidal topographic changes by swept source optical coherence tomography after photodynamic therapy for central serous chorioretinopathy. American Journal of Ophthalmology. 2014 Apr;157(4):852-60.

Purpose: To investigate the relationship between choroidal thickness and angiographic abnormalities in central serous chorioretinopathy (CSC) eyes by swept-source optical coherence tomography (swept-OCT), before and after half-fluence photodynamic therapy (PDT).
Design: Prospective interventional case series.
Methods: Consecutive patients presenting with treatment-naive active CSC underwent a complete ophthalmologic examination, including swept-OCT at study entry and at 7 days and 30 days after treatment with half-fluence PDT. The main outcome measures were changes in choroidal maps after PDT (mean ± SD) and the relationship between choroidal thickness and angiographic abnormalities.
Results: Of 12 patients (2 females, 10 males; mean age, 55.6 ± 14.0 years), 12 eyes were included. At study entry, mean choroidal thickness measured in the center of the fovea was significantly thicker in the study eyes as compared to the fellow eyes (420.7 ± 107.5 µm vs 349.2 ± 109.7 µm, respectively; P = 0.016). Mean choroidal thickness in the center of the fovea significantly decreased in the study eyes at both 7 days (380.2 ± 113 µm; P = 0.005) and 30 days after PDT (362.3 ± 111 µm; P = 0.002). A similar significant choroidal thinning was recorded in each early treatment of diabetic retinopathy study (ETDRS) applied to 3D swept-OCT maps. At each time point, mean choroidal thickness was significantly thicker in sectors with than in sectors without angiographic abnormalities (421 ± 102.4 µm vs 397.6 ± 96.5 µm, P = 0.002 at study entry; 381.2 ± 106.6 µm vs 364 ± 101.2 µm, P = 0.01 at day 7; 366.3 ± 103.2 µm vs 347.2 ± 99.6 µm at day 30).
Conclusions: Using swept-OCT, we demonstrated that in active CSC, choroidal thickness is increased to a greater extent in areas characterized by angiographic abnormalities. This increased choroidal thickness may persist even after PDT.

Significance: The SS-OCT prototype (Topcon) is a useful non-invasive technique to monitor and measure the choroid thickness in areas of angiographic abnormalities. Choroidal thickness changes are now being associated with a number of conditions previously assumed to be predominantely retinal in origin.

Link: http://www.ajo.com/article/S0002-9394(14)00009-9/abstract

Ueda-Arakawa N, Ooto S, Ellabban AA, Takahashi A, Oishi A, Tamura H, et al. Macular choroidal thickness and volume of eyes with reticular pseudodrusen using swept-source optical coherence tomography. American Journal of Ophthalmology. 2014 May;157(5):994-1004.

Purpose: To investigate the choroidal thickness/volume of eyes with reticular pseudodrusen using high-penetration swept-source optical coherence tomography (SS-OCT) and to evaluate the choroidal vasculature changes using en face images.
Design: Prospective cross-sectional study.
Methods: Thirty-eight eyes with reticular pseudodrusen and 14 normal eyes were studied with prototype SS-OCT. Eyes with reticular pseudodrusen were classified into 3 subgroups: eyes without late age-related macular degeneration (AMD) (Group 1) eyes with neovascular AMD (Group 2) and eyes with geographic atrophy (Group 3). Mean regional choroidal thickness/volume measurements were obtained by 3-dimensional (3D) raster scanning. The choroidal vascular area was measured using en face images reconstructed from a 3D SS-OCT data set.
Results: Mean age and axial length did not differ between eyes with reticular pseudodrusen and normal eyes. The mean choroidal thickness and volume of each sector was significantly reduced in eyes with reticular pseudodrusen compared with normal eyes ($P < .020$ for all). Mean choroidal thickness and volume of each area showed no significant difference between the 3 groups; however, most of them showed decreased thickness compared with normal eyes. En face images through the choroid revealed narrow and sparse choroidal vessels in eyes with reticular pseudodrusen. The area of choroidal vasculature was significantly reduced in eyes with reticular pseudodrusen compared with normal eyes ($P = .037$).
Conclusions: In eyes with reticular pseudodrusen, macular choroidal thickness/volume was reduced regardless of choroidal neovascularization/geographic atrophy. Thinned vessels in the choroid suggest choroidal involvement in the pathogenesis of reticular pseudodrusen.

Significance: This study confirms the ability of the DR OCT-1 Atlantis to precisely determine the choroid thickness in non-normal eyes and demonstrates the advantage of swept source en face images to represent the deep vascular structure, bringing new insights in to the pathogenesis of reticular pseudodrusen.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414000488

Ruiz-Medrano J, Flores-Moreno I, Pena-Garcia P, Montero JA, Duker JS, Ruiz-Moreno JM. Macular choroidal thickness profile in a healthy population measured by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2014 Jun;55(6):3532-42.

Purpose: To determine choroidal thickness (CT) profile in a healthy population using swept-source optical coherence tomography (SS-OCT).
Methods: This was a cross-sectional, noninterventional study. A total of 276 eyes (spherical equivalent ± 3 diopters [D]) were scanned with SS-OCT. Horizontal CT profile of the macula was created measuring subfoveal choroidal thickness (SFCT) from the posterior edge of retinal pigment epithelium (RPE) to the choroid-sclera junction. Three determinations were performed at successive points 1000 µm nasal and five more temporal to the fovea. Subjects were divided into five age groups.
Results: The mean SFCT was 301.89 ± 80.53 µm (95% confidence interval: 292.34-311.43). The mean horizontal macularchoroidal thickness (MCT) was 258.69 ± 64.59 µm (95% confidence interval: 251.04-266.35). No difference in CT was found between men and women. Mean SFCT of the different study groups was 325.6 ± 51.1 (0-10 years), 316.7 ± 90.1 (11-20 years), 313.9 ± 80.3 (21-40 years), 264.6 ± 79.3 (41-60 years), and 276.3 ± 88.8 µm in subjects older than 60 years ($P < 0.001$; ANOVA test). Mean horizontal MCT was 286.0 ± 43.5, 277.7 ± 68.2, 264.0 ± 61.9, 223.4 ± 62.2, and 229.7 ± 66.1 µm, respectively ($P < 0.001$; ANOVA test). The CT profile was different for each age group.
Conclusions: To our knowledge, this is the first population study of CT of healthy eyes across a broad range of age groups using SS-OCT. As has been determined using spectral-domain OCT, CT decreases with advancing age, especially after age 40. There were no differences due to sex. The greatest CT variation takes place in temporal sectors.

Significance: This is a large population study demonstrating the capacity of DRI OCT-1 Atlantis in measuring repeatedly and systematically the choroid thickness in a wide age group. Choroidal boundaries could be identified in 100% of eyes by both independent observers, compared to 63-93% of eyes assessed with SD OCT, as reported in previous studies.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2128233

Michalewski J, Michalewska Z, Nawrocka Z, Bednarski M, Nawrocki J. Correlation of choroidal thickness and volume measurements with axial length and age using swept source optical coherence tomography and optical low-coherence reflectometry. Biomed Research International. 2014;2014:639160.

Purpose: To report choroidal thickness and volume in healthy eyes using swept source optical coherence tomography (SS-OCT).
Methods: A prospective observational study of 122 patients examined with swept source OCT (DRI-OCT, Topcon, Japan). In each eye, we performed 256 horizontal scans, 12 mm in length and centered on the fovea. We calculated choroidal thickness manually with a built-in caliper and automatically using DRI-OCT mapping software. Choroidal volume was also automatically calculated. We measured axial length with optical low-coherence reflectometry (Lenstar LS 900, Haag-Streit, Switzerland).
Results: The choroid has focally increased thickness under the fovea. Choroid was thinnest in the outer nasal quadrant. In stepwise regression analysis, age was estimated as the most significant factor correlating with decreased choroidal thickness ($F=23.146$, $P<0.001$) followed by axial length ($F=4.902$, $P=0.03$). Refractive error was not statistically significant ($F=1.16$, $P=0.28$).
Conclusions: SS-OCT is the first commercially available system that can automatically create choroidal thickness and volume maps. Choroidal thickness is increased at the fovea and is thinnest nasally. Age and axial length are critical for the estimation of choroidal thickness and volume. Choroidal measurements derived from SS-OCT images have potential value for objectively documenting disease-related choroidal thickness abnormalities and monitoring progressive changes over time.

Significance: This study highlights the importance of accurate, automatic measurements of choroid thickness and volume, aided by swept source technology, and its role in a range of diseases.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4075071/

Michalewska Z, Michalewski J, Nawrocka Z, Dulczewska-Cichecka K, Nawrocki J. Suprachoroidal layer and suprachoroidal space delineating the outer margin of the choroid in swept-source optical coherence tomography. Retina. 2015 Feb;35(2):244-9.

Purpose: To define the morphology of outer choroidal margins in swept-source optical coherence tomography.
Methods: This is a prospective observational study of 180 eyes: 20 eyes of healthy volunteers, 20 eyes of myopic patients, and 20 eyes from each of the following groups: macular hole, lamellar macular hole, epiretinal membranes, drusen, dry age-related macular degeneration (AMD), neovascular AMD, and vitreomacular traction. A single 12-mm wide swept-source optical coherence tomography image for each of the examined eyes consisting of 1,024 A-scans has been created. The main outcome measure selected was to estimate the presence of suprachoroidal layer, as well as to estimate the ability to delineate the outer choroidoscleral boundary using the software available (DRI-OCT) and to determine its shape.
Results: Suprachoroidal layer was observed in 5% of healthy emmetropic eyes, in 50% of eyes with full-thickness macular holes, and in 60% of eyes with vitreomacular traction syndrome. It was also present in 50% of eyes with dry AMD and in 20% of eyes with neovascular AMD. The outer margin of the choroid in all eyes of the healthy volunteers and in eyes with macular diseases has been delineated correctly. In all healthy and myopic eyes, we recognized the outer choroidoscleral boundary as having a regular shape following the natural oval contour of the globe. In eyes with epiretinal membranes, macular hole, vitreomacular traction, and AMD, the outer choroidoscleral boundary was irregular; the choroid varied in thickness from point to point.
Conclusion: Swept-source optical coherence tomography enables exact visualization of the outer choroidoscleral boundary. Suprachoroidal layer consisting of two bands has been recognized, the upper of which is hyperreflective and the lower of which is hyporeflective. It may be supposed that the lower hyporeflective band corresponds to suprachoroidal space, which was not earlier visualized in vivo in eyes without choroidal effusion. Suprachoroidal layer in myopic and emmetropic healthy subjects has been rarely observed. We observed it more frequently in different macular diseases.

Significance: The DRI OCT-1 Atlantis allows a systematic detection of the outer choroidoscleral boundary, in healthy and pathological eyes, contributing to the correct measurement of the choroidal thickness. This paper highlights the importance of accurate choroidal thickness assessment in a range of different macular diseases.

Link:
http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2015&issue=02000&article=00010&type=abstract

Michalewska Z, Michalewski J, Adelman RA, Zawislak E, Nawrocki J. Choroidal thickness measured with swept source optical coherence tomography before and after vitrectomy with internal limiting membrane peeling for idiopathic epiretinal membranes. Retina. 2015 Mar;35(3):487-91.

Purpose: In eyes with epiretinal membranes (ERMs), retinal arteries become dilated and tortuous. This may correlate with the hemodynamics of the affected areas and possibly with choroidal thickness. The aim of this study was to estimate choroidal thickness before and after vitrectomy for idiopathic ERM in the operated eye and in the unaffected fellow eye.
Methods: A prospective study of 21 patients with idiopathic ERMs. We obtained swept source optical coherence tomography images that simultaneously evaluated the vitreous, retina, and choroid. We performed choroidal thickness measurements before pars plana vitrectomy with ERM removal and internal limiting membrane peeling. We took subsequent images 10 days and then 3 months after surgery. We compared the images with patients' fellow eyes. In each eye, we performed 256 horizontal scans, 12 mm in length and centered on the fovea. We manually calculated choroidal thickness from the posterior edge of the retinal pigment epithelium to the choroidoscleral boundary with the built-in caliper and additionally measured it automatically using DRI-OCT mapping software. We evaluated the outer choroidoscleral boundary and performed statistical analysis.
Results: We observed an ERM in 50% of fellow eyes. Mean choroidal thickness did not differ between study and fellow eyes (P = 0.67). Choroidal thickness decreased from 200 µm to 173 µm (P = 0.034) 3 months after vitrectomy and internal limiting membrane peeling. In all but two cases, the outer choroidoscleral boundary was irregular. Additionally, we observed that the suprachoroidal layer consists of two bands in four cases, an inner hyperreflective band and an outer hyporeflective one. We speculate the latter correlates with the suprachoroidal space.
Conclusion: Normalization of choroidal thickness after surgery suggests that there is some relationship between choroidal thickness and structure and the presence of idiopathic ERMs.

Significance: This paper suggests that the accurate assessment of choroidal thickness has a role to play in the management and monitoring of idiopathic ERM. Swept source technology allows the clear identification of the choroidoscleral boundaries.

Link:
http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2015&issue=03000&article=00016&type=abstract

Koizumi H, Kano M, Yamamoto A, Saito M, Maruko I, Kawasaki R, et al. Short-term changes in choroidal thickness after aflibercept therapy for neovascular age-related macular degeneration. American Journal of Ophthalmology. 2015 Apr;159(4):627-33.

Purpose: To investigate changes in choroidal thickness after aflibercept therapy for neovascular age-related macular degeneration (AMD).
Design: Retrospective, consecutive, interventional case series.
Methods: This study included 102 eyes of 102 patients with treatment-naïve neovascular AMD. All 102 eyes underwent 3 consecutive monthly 2.0 mg intravitreal aflibercept injections at baseline, 1 month, and 2 months. Choroidal thickness during 3 months were evaluated using either swept-source optical coherence tomography (OCT) or enhanced-depth imaging OCT.
Results: Of the 102 eyes, 46 eyes (45.1%) were diagnosed as typical neovascular AMD and 56 eyes (54.9%) as polypoidalchoroidal vasculopathy. After intravitreal aflibercept injections, the mean subfoveal choroidal thickness decreased from 252.0 ± 99.7 µm at baseline to 217.9 ± 95.6 µm at 3 months ($P < .0001$; percentage change from baseline, 86.5%). Mean choroidal thickness measured at 3 mm from the foveal center in the superior, inferior, temporal, and nasal directions also decreased significantly from 258.7 ± 85.9 µm to 236.4 ± 84.6 µm, 229.9 ± 93.0 µm to 208.6 ± 86.5 µm, 237.4 ± 86.5 µm to 214.6 ± 79.5 µm, and 183.7 ± 97.0 µm to 162.3 ± 90.6 µm, respectively ($P < .0001$ for all directions). Both subtypes of neovascular AMD demonstrated a similar trend toward decreasing choroidal thickness during the follow-up period.
Conclusions: Choroidal thickness significantly decreased not only at the foveal center but also in the entire macula after 3 monthly intravitreal aflibercept injections for neovascular AMD.

Significance: The high accuracy of DRI OCT-1 Atlantis in choroid thickness measurement is a valuable tool to assist in the follow-up of certain ophthalmic conditions. SD EDI OCT and SS OCT were not directly compared in this study since the instruments were located at different study sites, however measurements have been previously shown to be highly correlated.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414008356

Rim TH, Lee CS, Kim K, Kim SS. Assessment of choroidal thickness before and after steep Trendelenburg position using swept-source optical coherence tomography. British Journal of Ophthalmology. 2015 Apr;99(4):493-9.

Background: To evaluate changes in choroidal thickness before and after steep Trendelenburg position (STP, 40° head-down) using automated segmentation software to analyse swept-source optical coherence tomography (SS-OCT) data.
Methods: The eyes of 20 healthy volunteers underwent a three-dimensional wide scanning protocol with SS-OCT (Topcon, Tokyo, Japan) at baseline, immediately after STP was initiated, and 5, 10 and 15 min after STP; blood pressure and heart rate were measured concurrently. The predictive mean difference was calculated using a generalised linear mixed model that adjusted for potential confounders.
Results: Mean choroidal thickness significantly and transiently increased immediately (268.18±9.24 µm, $p<0.01$) and 5 min (264.25±9.30 µm, $p=0.03$) after STP, relative to baseline (256.51±9.20 µm). However, choroidal thickness decreased by 10 min (262.51±9.34 µm, $p=0.15$) and 15 min (261.38±9.40 µm, $p=0.37$) after STP. Mean arterial pressure also transiently increased from baseline (78.2±1.2 mm Hg) immediately after STP (79.9±1.1 mm Hg, $p=0.01$), but normalised by 5 min after STP ($p>0.05$ for all comparisons ≥5 min).
Conclusions: Choroidal thickness significantly but transiently increases after adopting STP, as evaluated by automated layer segmentation analysis of SS-OCT data.

Significance: This study describes the use of automated layer segmentation to measure the choroid thickness, a tool that reduces inaccuracies otherwise introduced by manual measurement.

Link: http://bjo.bmj.com/content/99/4/493.long

Shin YU, Lee MJ, Lee BR. Choroidal Maps in Different Types of Macular Edema in Branch Retinal Vein Occlusion Using Swept-Source Optical Coherence Tomography. American Journal of Ophthalmology. 2015 May 8.

Purpose: To compare choroidal thickness maps of different types of macular edema secondary to branch retinal vein occlusion (BRVO) using swept-source optical coherence tomography (SS OCT).
Design: Retrospective cross-sectional study.
Methods: We generated choroidal thickness maps of 55 eyes of 55 patients with BRVO using the macular volumetric raster scan protocol of the SS OCT. The enrolled eyes were classified into 4 types of macular edema according to the captured OCT images: no macular edema (nME, 13 eyes), cystoid macular edema (CME, 15 eyes), serous retinal detachment (SRD, 12 eyes), and mixed type (CME + SRD, 15 eyes). The data from normal fellow eyes served as the control. Statistical analysis was performed to compare choroidal thickness maps according to the type of macular edema.
Results: The mean choroidal thicknesses in the control, nME, CME, SRD, and mixed-type groups were 205.77 ± 41.65 μm, 211.56 ± 46.34 μm, 214.30 ± 49.21 μm, 249.18 ± 43.51 μm, and 248.05 ± 49.51 μm, respectively. No statistical difference in choroidal thickness was observed among the nME, CME, and control groups, while the SRD and mixed groups showed larger choroidal thickness values than the control group ($P < .001$). No topographic feature in the choroidal thickness was observed to vary according to the location of BRVO.
Conclusions: The results suggest the choroidal thickness in BRVO varies according to the type of macular edema. Among the macular edema groups, choroidal thickness was significantly increased in eyes with SRD relative to those without SRD, which suggests that increased choroidal thickness may influence the development of SRD in BRVO.

Significance: The DRI OCT-1 Atlantis allows the automatic and detailed measurement of choroidal thickness in eyes with associated pathology, enabling identification of regional variations in choroidal thickness. Choroidal thickness changes are being associated with an increasing range of retinal conditions, and accurate thickness assessment is likely to be important going forward.

Link: http://www.ajo.com/article/S0002-9394(15)00270-6/abstract

Ruiz-Medrano J, Flores-Moreno I, Montero JA, Duker JS, Ruiz-Moreno JM. Morphologic Features of the Choroidoscleral Interface in a Healthy Population Using Swept-Source Optical Coherence Tomography. American Journal of Ophthalmology. 2015 Jun 2.

Objective: To analyze the morphologic features of the choroidoscleral interface in a healthy population using swept-source optical coherence tomography (SS OCT).
Design: Retrospective data analysis of a subgroup of eyes from a previous single-center, prospective, cross-sectional, noninterventional study.
Methods: A total of 276 healthy eyes from 154 subjects were evaluated using SS OCT. Inclusion criteria were best-corrected visual acuity between 20/20 and 20/25, spherical equivalent between ±3 diopters, and no systemic or ocular diseases. Two independent investigators analyzed the morphologic features of the choroidoscleral interface in a masked fashion, classifying the contour and shape as concave (bowl-shaped) or inflective (S-shaped contour with ≥1 inflection point).
Results: The presence of a temporal choroidoscleral interface inflection was identified in 12.8% of the eyes. The mean choroidal thickness was 372.1 ± 76.8 µm and the average distance from the inflection point to the fovea was 4427.3 ± 627.9 µm. Nine patients showed an inflective profile in both eyes. No changes in the retinal profile were found in any of these cases. The mean age of the patients with an inflective profile was 16 ± 19 years (range 4-82) vs 36 ± 25 years (range 3-95) in the group with a concave contour (P = .001). The temporal choroidal thickness at 4000 and 5000 µm from the fovea was thicker in the group with a concave contour.
Conclusions: Temporal choroidoscleral interface inflection or S-shaped profile of the choroidoscleral interface with focal thinning of the choroid can be considered a normal variation without clinical significance, especially in younger populations.

Significance This study uses a SS-OCT prototype (Topcon) to systematically describe the choroidal thickness profile in a large population group. Precise boundary locations can be identified due to the superior penetration of swept source technology.

Link: http://www.ajo.com/article/S0002-9394(15)00312-8/abstract

Ruiz-Medrano J, Flores-Moreno I, Pena-Garcia P, Montero JA, Duker JS, Ruiz-Moreno JM. Asymmetry in macular choroidal thickness profile between both eyes in a healthy population measured by swept-source optical coherence tomography. Retina. 2015 May 5

Purpose: To determine the difference in macular choroidal thickness (CT) profile between eyes in healthy individuals using swept-source optical coherence tomography.
Design: Cross-sectional noninterventional study.
Participants: One hundred and forty eyes from 70 healthy patients with spherical equivalent between ±3 D and with difference #0.25 D between eyes were scanned using a swept-source optical coherence tomography (Topcon Corporation).
Methods: Cross-sectional noninterventional study. One hundred and forty eyes from 70 healthy patients with spherical equivalent between ±3D and with difference ≤0.25D between eyes were scanned using a swept-source optical coherence tomography (TopconCorporation). A horizontal CT profile of the macula was created in both eyes by manually measuring the subfoveal CT from the posterior edge of retinal pigment epithelium (RPE) to the choroid/sclera junction. Three determinations were performed at successive points 1,000 mm nasal to the fovea and 5 more CT between both eyes were analysed temporal to the fovea.
Results: Mean age was 25.4 ± 19.9 years (from 4 to 75). The mean spherical equivalent was 0.18 ± 1.37 D (from −3 to +3). Mean macular nasal CT was thicker in the right eye (RE) than in the left eye (LE) (228.11 ± 69.23 mm vs. 212.27 ± 62.71 mm; P = 0.0002; Student's t-test paired data). Mean subfoveal CT and mean temporal CT was not statistically significantly different between the eyes. No statistically significant differences were observed comparing spherical equivalent in the RE compared with the LE. Both men and women showed a thicker mean nasal choroid in the RE versus the left (men, 226.97 ± 61.56 mm vs. 209.87 ± 60.31 mm; women, 229.63 ± 79.39 mm vs. 215.47 ± 66.68 mm, P = 0.003 and P = 0.03, respectively; Student's t-test paired data). At each nasal determination, CT in the RE was statistically significantly thicker than the LE (N1: 283.72 ± 81.10 mm vs. 269.76 ± 75.81 mm [P = 0.001]; in N2: 230.45 ± 73.47 mm vs. 211.33 ± 66.92 mm [P = 0.0002]; and in N3: 170.16 ± 61.00 mm vs. 155.72 ± 53.87 mm [P = 0.008], respectively).
Conclusion: To the best of our knowledge, this is the first report suggesting thicker macular nasal choroid in the RE compared with the LE. In contrast, subfoveal CT and temporal CT were not found to be different between eyes.

Significance: Swept Source OCT (Topcon) allows consistent manual measurements of choroidal thickness providing an accurate characterization of the choroidal thickness that is operator independent. Swept source allows precise identification of the choroidoscleral boundaries and hence the detection of subtle asymmetries in choroidal thickness.

Link: http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2015&issue=10000&article=00019&type=abstract

Razavi S, Souied EH, Darvizeh F, Querques G. Assessment of Choroidal Topographic Changes by Swept-Source Optical Coherence Tomography After Intravitreal Ranibizumab for Exudative Age-Related Macular Degeneration. American Journal of Ophthalmology. 2015 Aug 12.

Purpose: To investigate choroidal topographic changes by swept-source optical coherence tomography (Swept-OCT) in patients undergoing intravitreal injections of anti-vascular endothelial growth factor (VEGF) for exudative age-related macular degeneration (AMD).
Design: Prospective interventional study.
Methods: Consecutive patients with unilateral treatment-naïve exudative AMD were entered into the study over 6 months. Changes in choroidal thickness after intravitreal ranibizumab injections, overall in the macular and in neovascular and non-neovascular areas, from baseline to month 3 (loading phase) and month 6 (pro re nata phase), were investigated by means of Swept-OCT maps.
Results: Forty-one eyes of 41 patients (mean age: 79.4 ± 7.3 years) were analyzed. Choroidal thickness at study entry was significantly thicker in the study eyes as compared to fellow eyes ($P < .05$). Analysis of sectorial choroidal thickness over time in study eyes revealed a significant reduction in both neovascular and non-neovascular areas from baseline to month 3 and month 6 ($P < .0001$ for all). Central choroidal thickness revealed significant variation between treated and fellow eyes from baseline to month 3 ($P = .017$) and month 6 ($P = .045$). The visual gain was significantly higher ($P = .02$) in patients with a larger choroidal thickness reduction (≥29 µm, n = 11) vs the others (n = 30).
Conclusions: The thinning of the macular choroid (affected or not by choroidal neovascularization), along with the significantly thicker choroid in exudative AMD eyes before treatment initiation compared to fellow eyes, allows the hypothesis that anti-VEGF treatment may favorably influence the choroidal exudation by reducing choroidal vascular hyperpermeability

Significance: The accuracy of SS-OCT (Topcon) in choroid thickness measurements allows more precise follow up of patients age related macular degeneration.

Link:: http://www.sciencedirect.com/science/article/pii/S0002939415004705

Capuano V, Souied EH, Miere A, Jung C, Costanzo E, Querques G. Choroidal maps in non-exudative age-related macular degeneration. British Journal of Ophthalmology. 2015 Sep 7.

Purpose: To compare choroidal thickness maps (CMs) in patients with non-exudative age-related macular degeneration (AMD) and control subjects using swept source optical coherence tomography (Swept-OCT).
Methods: CMs were automatically measured in the different Early Treatment of Diabetic Retinopathy Study (ETDRS) sectors in eyes with early non-exudative AMD (early AMD) (large soft drusen: group 1; reticular pseudodrusen: group 2 and variable combination of large soft drusen and reticular pseudodrusen: group 3), late non-exudative AMD/geographic atrophy (GA) (late AMD) (group 4) and control subjects (group 5). Fundus autofluorescence (FAF) images were overlaid to sectorial CMs in late-AMD group (group 4).
Results: A total of 90 eyes (90 patients, 79.7±8.34 years old) were included. CMs were significantly reduced in early-AMD group 2 and 3 and late-AMD group 4 compared with control subjects in group 5 and early-AMD group 1 (large soft drusen alone) for each ETDRS sectors ($p<0.05$). No difference in CMs was found by comparing group 2 with 3 and group 2 and 3 with group 4. No statistical differences in CMs were found among ETDRS sectors with >50% absence of FAF ('Hypo FAF' sectors) resulting from retinal atrophy versus ≤50% absence of FAF ('hyper/iso FAF' sectors owing to >50% preserved retina) in late-AMD group (group 4) ($p=0.328$).
Conclusions: CMs appeared thinner in early non-exudative AMD with intermediate distribution of reticular pseudodrusen versus control subjects and early non-exudative AMD with drusen alone. The same results were found in the group with variable combination of large soft drusen and reticular pseudodrusen. In GA eyes, a choroidal thinning could be detected independently of the retinal pigmented epithelium status.

Significance: The ability of SS OCT (DRI OCT-1 Atlantis) in reliably and systematically identifying the choroidosceral interface and measuring the thickness of the choroid, improves the characterization of pathological conditions.

Link: http://bjo.bmj.com/content/early/2015/09/07/bjophthalmol-2015-307169.long

Swept Source Optical Coherence Tomography –

Vitreous

Itakura H, Kishi S, Li D, Akiyama H. Observation of posterior precortical vitreous pocket using swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2013 May;54(5):3102-7.

Purpose: To observe posterior precortical vitreous pockets (PPVPs) using swept-source optical coherence tomography (SS-OCT).
Methods: We performed SS-OCT in both eyes of 58 volunteers (36 men, 22 women) using 12-mm horizontal vertical scans through the macula and optic disc. To minimize age-related changes (liquefaction or posterior vitreous detachment), all subjects were a mean of 26.2 years (range, 22–40 years). The refractive errors ranged from −9.5 diopters (D) to +3.0 D. To estimate the PPVP size, we measured the height between the fovea and the anterior border of the PPVP and the maximal width in the 12-mm horizontal scan through the fovea and disc.
Results: SS-OCT visualized the PPVPs as boat-shaped lacunae in the macular area bilaterally in all subjects (maximal width, 3114–9887 µm; mean width, 6420.6; central height, 208–1877 µm; mean height, 708.1 in the right eyes, with no significant difference in the left eyes). There was a significant correlation between the PPVP height and myopic refractive error. The posterior wall of the PPVP was a thin vitreous cortex, thinnest at the fovea. The septum was between the nasal border of the pocket and Cloquet's canal, which extended forward and tilted superiorly in all cases. A channel connected Cloquet's canal and the PPVPs bilaterally in 54 (93.1%) of 58 cases.
Conclusions: SS-OCT clarified the boat-shaped PPVP structure in vivo. Although the central height increased with the myopic refractive error, the width was unchanged. A channel connecting Cloquet's canal and PPVP suggested the route of aqueous humor into the PPVP.

Significance: The superior contrast of vitreous images provided by swept source OCT, shows in detail the structure of posterior vitreous pockets in vivo.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2188984

Stanga PE, Sala-Puigdollers A, Caputo S, Jaberansari H, Cien M, Gray J, et al. In vivo imaging of cortical vitreous using 1050-nm swept-source deep range imaging optical coherence tomography. American Journal of Ophthalmology. 2014 Feb;157(2):397-404 e2.

Purpose: To image the cortical vitreous, determine the prevalence of the bursa premacularis and space of Martegiani, and measure the dimensions of the bursa using the new 1050-nm swept-source deep range imaging optical coherence tomography (DRI OCT-1 Atlantis).
Design: Retrospective cross-sectional study.
Methods: One hundred and nineteen consecutive patients (5-100 years) underwent an OCT scan using 1050-nm swept-source deep range imaging optical coherence tomography. Prevalence of the bursa premacularis and space of Martegiani and the stage of posterior vitreous detachment (PVD) were determined. The horizontal (width) and anteroposterior (depth) dimensions of the bursa were recorded along with the patient's age.
Results: A bursa was detected in 57.1% (136/238) of eyes. The bursa and space of Martegiani coexisted in 97.8% of eyes. Prevalence of detected bursa was 84.5% in eyes with either no PVD or perifoveal PVD only; the prevalence fell with further increases in the extent of PVD. Prevalence of detected bursa was 75.4% in patient group aged 0-60 years and 38% in the group aged 60-100 years. Mean width was 7001 µm (range: 3354-10 316 µm, SD: 1412 µm). Mean depth was 416 µm (range: 31-1189 µm, SD: 187 µm). Width and depth of the bursa did not correlate with age (R(2) width = 0.0316; R(2) depth = 0.0108). Bilateral bursa tended to be symmetrical in width but less so in depth (R(2) width = 0.63, $P < .001$; R(2) depth = 0.33, $P < .001$).
Conclusion: Swept-source OCT has allowed us to demonstrate the almost invariable coexistence of the bursa premacularis and space of Martegiani. Swept-source OCT can image both in patients from as early as the first to as late as the tenth decade of life.

Significance: The high scanning speed of DRI OCT-1 Atlantis compensates the movement of vitreous fibers and the longer wavelength produces less scattering. The conjugation of these two factors allows the visualization of cortical vitreous. Because of the speed of acquisition, scans can easily be captured in young children and the elderly.

Link: http://www.ajo.com/article/S0002-9394(13)00689-2/abstract

Li D, Kishi S, Itakura H, Ikeda F, Akiyama H. Posterior precortical vitreous pockets and connecting channels in children on swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2014 Apr;55(4):2412-6.

Purpose: We observed the posterior vitreous in children using swept source optical coherence tomography (SS-OCT).
Methods: The normal right eyes of 73 children (ages, 3-11 years) were studied using SS-OCT with 12-mm horizontal and vertical scans in the posterior fundus.
Results: Posterior precortical vitreous pockets (PPVPs), narrow liquefied spaces along the vitreoretinal interface in the macula (mean, 165.4 ± 35.2 µm [depth] × 3327 ± 615.7 µm [width]), were observed at age 3 in horizontal scans. The PPVPs enlarged to 382.9 ± 51.8 × 4486.5 ± 342.3 from ages 4 to 6 ($P < 0.01$) and 524.9 ± 60.3 × 5485.9 ± 307.5 after age 7 ($P < 0.01$). In all subjects, the depth and width were means of 426.4 ± 38.2 and 4834.4 ± 228.1 µm, respectively. There were significant correlations between the PPVP size and age (PPVP depth, $r = 0.42$, $P < 0.001$; PPVP width, $r = 0.42$, $P < 0.001$), but not refractive error. The PPVP posterior wall was not visible in all eyes. The PPVP and Cloquet's canal appeared as separate spaces at ages 3 and 4 years. The connecting channel between the PPVPs and Cloquet's developed in 7.7%, 11.1%, 12.5%, 27.3%, 40%, 37.5%, and 50% at ages 5, 6, 7, 8, 9, 10, and 11, respectively.
Conclusions: The PPVPs emerged in front of the macula as a solitary space in early childhood. They first were narrow liquefied spaces anterior to the macula at age 3 and evolved to small boat-shaped spaces that gradually enlarged with age. The channels connecting the PPVPs and Cloquet's canal begin to form after age 5. Their presence suggests a physiologic role of the PPVPs.

Significance: The wide and deep scan window of swept source OCT (DRI OCT-1 Atlantis in this example), allows the visualization of the entire structure of posterior vitreous pockets. Scans can be easily captured in very young children, aided by the speed of acquisition.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2190025

Muqit MM, Stanga PE. Swept-source optical coherence tomography imaging of the cortical vitreous and the vitreoretinal interface in proliferative diabetic retinopathy: assessment of vitreoschisis, neovascularisation and the internal limiting membrane. British Journal of Ophthalmology. 2014 Jul;98(7):994-7.

Summary: Anomalous posterior vitreous detachment leads to shrinkage of the inner vitreous with the outer precortical vitreous cortex remaining attached to the macula and retina, resulting in vitreoschisis. Sebag and coworkers have reported vitreoschisis in macular disorders, and vitreoschisis has been demonstrated using ultrasonography and histopathology. Swept-source OCT (SS-OCT) is a new imaging technology (Atlantis DRI-OCT-1, Topcon, Japan). We demonstrate for the first time in vivo the microstructural tomographic features of and spatial vitreoretinal relationships between vitreoschisis, retinal and optic nerve head neovascularisation, detachment of the internal limiting membrane (ILM) and traction on the neuroretina in proliferative diabetic retinopathy (PDR).

Significance: This case report demonstrates the ability of DRI OCT-1 in imaging the posterior cortical vitreous and the fact that it can contribute to a better diagnosis of conditions affecting that region of the eye.

Link: http://bjo.bmj.com/content/98/7/994.extract

Schaal KB, Pang CE, Pozzoni MC, Engelbert M. The premacular bursa's shape revealed in vivo by swept-source optical coherence tomography. Ophthalmology. 2014 May;121(5):1020-8.

Objective: To resolve the controversy surrounding the shape and relationship of posterior vitreous spaces by characterizing the connections between the premacular bursa, the area of Martegiani, and Cloquet's canal.
Design: Comprehensive posterior vitreous maps were created using swept-source optical coherence tomography (SS OCT) in a cross-sectional study.
Participants: The posterior vitreous of 102 eyes of 51 volunteers 21 to 54 years of age without ocular pathologic features was imaged using SS OCT.
Methods: The DRI OCT-1 Atlantis 3D SS OCT (Topcon Medical Systems, Oakland, NJ) was used to acquire scans of the posterior vitreous over an 18×18-mm area.
Main Outcome and Measures: Posterior vitreous spaces and their relationships were identified.
Results: The premacular bursa was identified in all 102 eyes and was found to extend superiorly beyond our scanning ability at a variable angle. No discernible superior borders could be identified. Instead, a connection of the bursa with the preoptic area of Martegiani or its extension, Cloquet's canal, was found in 101 of 102 eyes. This connection occurred at a variable distance from the optic nerve, where it formed a flat and broad superior channel. The skyward direction of this channel was found to be gravity dependent in all 14 eyes of the 7 subjects examined in various head positions. Although SS OCT was able to identify vitreous degeneration, the above changes were present in 28 eyes even without any discernible vitreous degeneration.
Conclusion: The premacular bursa, also called the posterior precortical vitreous pocket, was found to continue superiorly beyond the posterior pole without a detectable border. The bursa fused broadly with the extension of the preoptic area of Martegiani, namely Cloquet's canal, or the hyaloidal tract of Eisner. These findings suggest that there is a direct anteroposterior connection between the retrolental and premacular and preoptic spaces already existent in the eyes of young adults before the occurrence of vitreous degeneration. This observation may have important implications with respect to the movement of intrinsic and extrinsic mediators between the anterior and posterior segments.
Erratum in: Ophthalmology. 2014 Aug;121(8):1666.

Significance: The ability of swept source OCT (DRI OCT-1 Atlantis in this paper) to image the posterior vitreous provides a better understanding of the vitreous anatomic features.

Link: http://www.sciencedirect.com/science/article/pii/S0161642013011123

Spaide RF. Visualization of the posterior vitreous with dynamic focusing and windowed averaging swept source optical coherence tomography. American Journal of Ophthalmology. 2014 Dec;158(6):1267-74.

Purpose: To survey the anatomic structures seen in the posterior vitreous using a newly developed technique, dynamic focusing and windowed averaging swept source optical coherence tomography.
Design: A cross-sectional study of subjects without a history of eye disease or posterior vitreous detachment.
Methods: A focused illumination beam was swept through the scan depth during 96 successive B-scans and the corresponding most highly resolved portion of each scan was used to make an averaged composite image. The main outcome measures were the frequency and interconnectedness of anatomic features visualized.
Results: There were 44 eyes of 25 subjects, who ranged in age from 23 to 62. An optically empty space was seen above the macula in all eyes, and corresponded to the premacular bursa. Above the optic nerve head was a conical space corresponding to the area of Martegiani. The 2 areas were interconnected in 25 cases (56.8%). Anterior to the premacular bursa was another lacuna, named the supramacular bursa, that was separate from the premacular bursa in horizontal scans centered on the fovea and was found in 38 eyes (86.4%). Both the supramacular and premacular bursae coursed anteriorly and in 21 of the 38 eyes (55.3%) were seen to interconnect.
Conclusions: The anatomic arrangement of the vitreous is consistent in living eyes with no posterior vitreous detachment, and does not correspond precisely to that described from dissection studies of autopsy specimens. The constancy of the specific findings suggests there may be some beneficial effect from the architectural structure of the vitreous that enhances evolutionary fitness.

Significance: This study describes a technique based on SS-OCT (DRI-OCT-1 Atlantis) that aims to improve vitreous visibility. The procedure consists of averaging multiple scans from a region of interest and leads to enhanced image quality.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414005376

Pang CE, Schaal KB, Engelbert M. Association of prevascular vitreous fissures and cisterns with vitreous degeneration as assessed by swept source optical coherence tomography. Retina. 2015 Apr 13.

Purpose: To demonstrate the presence of prevascular vitreous fissures (PVF) and posterior vitreous cisterns in vivo and correlate with the degree of vitreous degeneration (VD).
Methods: This was a cross-sectional study using Topcon Deep Range Imaging OCT-1 Atlantis 3D swept source optical coherence tomography for acquiring scans of posterior vitreous covering an 18 × 18-mm area in 104 eyes of 52 healthy volunteers without posterior vitreous detachment.
Results: We observed that increasing age was associated with higher VD grades ($P < 0.05$). Prevascular vitreous fissures, characterized by areas of lower optical density overlying the retinal blood vessels, were identified in 93 (89%) eyes, and the presence of PVF correlated with lower VD grades ($P < 0.05$). Presence of cisterns correlated with higher VD grades ($P < 0.05$). All eyes with absence of PVF were found to have established cisterns. Prevascular vitreous fissures were connected with cisterns in 44 of the 71 (62%) eyes with cisterns, while the base of the cistern was directly above retinal blood vessels in 38 (54%) eyes, which suggests that the cisterns could be derived from PVF.
Conclusion: Swept source optical coherence tomography imaging can identify PVF and cisterns occurring in the context of age-related VD, and PVF appeared to be possible precursors of cisterns.

Significance: The swept source DRI OCT-1 Atlantis providing clarity from vitreous to choroid and deeper, allows detailed analysis of the posterior vitreous anatomy that may be helpful in grading vitreous degeneration and understanding of vitreoretinal interface diseases.

Link:
http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=9000&issue=00000&article=98011&type=abstract

Yokoi T, Nakayama Y, Nishina S, Azuma N. Abnormal traction of the vitreous detected by swept-source optical coherence tomography is related to the maculopathy associated with optic disc pits. Graefe's Archive for Clinical and Experimental Ophthalmology. 2015 Aug 6.

Background: Maculopathy associated with optic disc pits (ODP), which sometimes causes severe visual loss, usually appears in late childhood or early adulthood. However, it has long been unclear how the disease begins to develop at these ages. We evaluated the relationship between vitreous structure and maculopathy associated with ODP.
Methods: Six patients (seven eyes) with ODP were diagnosed between July 1990 and May 2013. Fundus photographs and swept-source optical coherence tomography (SS-OCT) images were evaluated retrospectively, and the vitreous at the vitreoretinal interface was visualized by reconstructing three-dimensional SS-OCT images. Vitrectomy was performed in the eyes with maculopathy.
Results: Among the six patients, five had ODP in one eye each and one patient had bilateral ODP. The pits were mainly located in the temporal quadrant, and maculopathy, including retinoschisis and retinal detachment, was detected in five eyes associated only with the temporal pits. A flat retinal detachment was observed in four eyes and identified within the vascular arcade except in one eye. A posterior precortical vitreous pocket (PPVP) was observed in all eyes except in one eye without maculopathy. Reconstructing images from SS-OCT showed the vitreoretinal interface abnormalities around the optic disc and the macular area in all eyes, which was completely different from the vitreoretinal interface in the normal pediatric eye. Vitrectomy was performed in four eyes with retinal detachment to resect the abnormal vitreous traction. Posterior vitreous detachment was created in two eyes. Retinal reattachment was achieved in three eyes, and subretinal fluid receded in one eye. The visual acuity improved in all four eyes.
Conclusions: Abnormal traction of the vitreous due to an abnormality of the vitreoretinal interface, which may be strengthened by the development of a PPVP, generates the maculopathy associated with ODP.

Significance: Using en face software, SS-OCT enables the in vivo visualization of the vitreoretinal interface and the identification of abnormal vitreous traction as an important element in maculopathy associated with ODP.

Link:http://link.springer.com/article/10.1007%2Fs00417-015-3114-z

Chen KC, Jung JJ, Engelbert M. Giant premacular bursa: a novel finding of the posterior vitreous in two patients with Stickler syndrome type 1 revealed by swept-source optical coherence tomography. Graefe's Archive for Clinical and Experimental Ophthalmology. 2015 Aug 6.

Summary: Characteristic changes within the retrolental vitreous in Stickler syndrome type 1 (STL1) have been identified with slit lamp biomicroscopy. However, imaging of the posterior vitreous has been lacking, relying only on B-scan ultrasound and time-domain optical coherence tomography (TD-OCT). Herein, we report the first swept-source optical coherence tomography (SS-OCT) images of the posterior vitreous anatomy in a father and son with genetically-confirmed STL1

Significance: The resolution and wide window imaging of the DRI OCT-1 Atlantis enables a better characterization of the posterior vitreous.

Link: http://link.springer.com/article/10.1007%2Fs00417-015-3125-9

Itakura H, Kishi S, Li D, Akiyama H. En face imaging of posterior precortical vitreous pockets using swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2015 May 1;56(5):2898-900.

Purpose: To observe posterior precortical vitreous pockets (PPVPs) using swept-source optical coherence tomography (SS-OCT).
Methods: We performed SS-OCT in both eyes of 58 volunteers (36 men, 22 women) using 12-mm horizontal vertical scans through the macula and optic disc. To minimize age-related changes (liquefaction or posterior vitreous detachment), all subjects were a mean of 26.2 years (range, 22-40 years). The refractive errors ranged from -9.5 diopters (D) to +3.0 D. To estimate the PPVP size, we measured the height between the fovea and the anterior border of the PPVP and the maximal width in the 12-mm horizontal scan through the fovea and disc.
Results: SS-OCT visualized the PPVPs as boat-shaped lacunae in the macular area bilaterally in all subjects (maximal width, 3114-9887 µm; mean width, 6420.6; central height, 208-1877 µm; mean height, 708.1 in the right eyes, with no significant difference in the left eyes). There was a significant correlation between the PPVP height and myopic refractive error. The posterior wall of the PPVP was a thin vitreous cortex, thinnest at the fovea. The septum was between the nasal border of the pocket and Cloquet's canal, which extended forward and tilted superiorly in all cases. A channel connected Cloquet's canal and the PPVPs bilaterally in 54 (93.1%) of 58 cases.
Conclusions: SS-OCT clarified the boat-shaped PPVP structure in vivo. Although the central height increased with the myopic refractive error, the width was unchanged. A channel connecting Cloquet's canal and PPVP suggested the route of aqueous humor into the PPVP

Significance: Swept source OCT (DRI OCT-1 Atlantis) allows the visualization of the vitreous by en face imaging providing novel visualization of this structure and identifying previously unseen features associated with myopia.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2188984

Swept Source Optical Coherence Tomography –

Myopia Application

Ohno-Matsui K, Akiba M, Moriyama M, Ishibashi T, Tokoro T, Spaide RF. Imaging retrobulbar subarachnoid space around optic nerve by swept-source optical coherence tomography in eyes with pathologic myopia. Investigative Ophthalmology and Vision Science. 2011 Dec;52(13):9644-50.

Purpose: To examine the subarachnoid space (SAS) of eyes with pathological myopia and analyze the characteristics of the SAS and the surrounding tissues by swept-source optical coherence tomography (OCT).

Methods: One hundred thirty-three eyes of 76 patients with pathologic myopia (spherical equivalent refractive error of >-8.00 diopters (D) or an axial length >26.5 mm) and 32 eyes of 32 subjects with emmetropia were enrolled. The eyes in both groups were not tested to determine whether glaucoma was present. The papillary and peripapillary areas were examined with a swept-source OCT prototype system that uses a wavelength sweeping laser operated at 100,000 Hz A-scan repetition rate in 1-µm wavelength.

Results: In the B-scan images, the arachnoid trabeculae inside the SAS were clearly observed as a pattern of reticular lines and dots interspersed with hyporeflective zones consistent with fluid, whereas orbital fat had more uniform features with gray intervening spaces. The SAS was triangular, with the base toward the eye surrounding the optic nerve in the region of the scleral flange. An SAS was found in 124 highly myopic eyes (93.2%) but not in the emmetropic eyes. The shortest distance between the inner surface of lamina cribrosa and SAS was 252.4 ± 110.9 µm, and the thinnest region of peripapillary sclera above SAS (scleral flange thickness) was 190.6 ± 51.2 µm. In one myopic patient, there appeared to be direct communication between the intraocular cavity and SAS through pit like pores.

Conclusions: Optic SAS is seen in 93% of highly myopic eyes, and the SAS appears to be dilated in highly myopic eyes. The expanded area of exposure to CSF pressure along with thinning of the posterior eye wall may influence staphyloma formation and the way in which certain diseases, such as glaucoma, are manifested.

Significance: The higher penetration of SS-OCT allows the detection of subarachnoid spaces in the majority of highly myopic eyes, surrounding the optic nerve posterior to the globe, a feature not visible by conventional SD-OCT. This feature may have implications for glaucoma and other diseases associated with myopia, because of the increased exposure of the eye to pressure from the cerebrospinal fluid.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2187190

Maruko I, Iida T, Sugano Y, Oyamada H, Akiba M, Sekiryu T. Morphologic analysis in pathologic myopia using high-penetration optical coherence tomography. Investigative Ophthalmology and Vision Science. 2012 Jun;53(7):3834-8.

Purpose: We evaluated retrospectively the morphologic choroidal and scleral characteristics in eyes with pathologic myopia using high-penetration optical coherence tomography (HP-OCT) also known as swept-source OCT (SS-OCT).
Methods: The subfoveal choroidal and scleral thicknesses were measured using the prototype HP-OCT with a 1060 nm light source. We also measured the scleral thickness 3 mm superior, inferior, nasal, and temporal to the fovea on the horizontal and vertical OCT sections. The axial length (AL) in all eyes was measured using optical biometry.
Results: We examined 58 eyes of 35 patients (7 men and 28 women, mean age 65.5 years) with an AL exceeding 26.5 mm. The mean AL was 29.0 ± 1.4 mm. The full-thickness choroid and sclera were visualized in all eyes. The mean subfoveal choroidal and scleral thicknesses were 52 ± 38 and 335 ± 130 µm, respectively. The mean scleral thicknesses 3 mm superior, inferior, nasal, and temporal to the fovea were 266 ± 78 (n = 57), 259 ± 72 (n = 56), 324 ± 109 (n = 39), and 253 ± 79 (n = 58) µm, respectively. The subfoveal sclera was thicker than 3 mm outside the fovea ($P < 0.05$, for each comparison).
Conclusions: The full-thickness choroid and sclera in all eyes with pathologic myopia were visualized using a prototype HP-OCT. The subfoveal sclera was thicker than 3 mm outside the fovea. HP-OCT is a useful tool for morphologic analyses of pathologic myopia.

Significance: This study employs the deeper penetration of SS-OCT (prototype) to measure full choroid and scleral thickness in myopic eyes.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2128376

Ohno-Matsui K, Akiba M, Ishibashi T, Moriyama M. Observations of vascular structures within and posterior to sclera in eyes with pathologic myopia by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2012 Oct;53(11):7290-8.

Purpose: We examined the intrascleral and retrobulbar blood vessels in highly myopic eyes by swept-source optical coherence tomography (swept-source OCT).
Methods: We included in the study 662 of 357 patients with pathologic myopia (spherical equivalent of myopic refractive error ≥ 8.00 diopters or axial length > 26.5 mm). A swept-source OCT system that uses a wavelength sweeping laser with A-scan repetition rate of 100,000 Hz and 1 µm wavelength was used. Radial scans along 12 meridians of 12 mm scan length centered on the fovea were made. Indocyanine green angiography (ICGA) also was performed to identify the intrascleral and retrobulbar vessels that were observed by swept-source OCT.
Results: Intrascleral and retrobulbar blood vessels were observed in the macular area of the highly myopic eyes. Linear hyporeflective structures running in the sclera were observed in 474 of the 662 myopic eyes, and ICGA confirmed that these structures were the long posterior ciliary arteries (LPCAs) or the short posterior ciliary arteries (SPCAs) whose entry sites into the eye were displaced toward the temporal edge of the posterior staphyloma in 50 eyes. In 36 of the 662 eyes (5.4%), cross sections of the blood vessels were seen coursing through the scleral layer. In 177 of these 443 eyes, the retrobulbar posterior ciliary arteries (PCAs) also were observed as a cluster of circular or curved hyporeflectant structures just posterior to the sclera.
Conclusions: Swept-source OCT is a high-quality method to detect intrascleral and retroscleral blood vessels in the eyes with pathologic myopia. These findings and longitudinal studies of these vessels will help in investigating how they are altered in pathologic myopia, and how such alterations are related to the complications in the retina-choroid and optic nerve.

Significance: This study demonstrates that the SS-OCT prototype (Topcon) is able to trace the course of vessels within and posterior to the sclera. This is possible because of the long wavelength and limited reduction in signal to noise ratio with depth, compared to SD-OCT.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2127943

Ohno-Matsui K, Akiba M, Modegi T, Tomita M, Ishibashi T, Tokoro T, et al. Association between shape of sclera and myopic retinochoroidal lesions in patients with pathologic myopia. Investigative Ophthalmology and Vision Science. 2012 Sep;53(10):6046-61.

Purpose: The purpose of the study was to analyze the shape of the sclera determined by swept-source optical coherence tomography (OCT) and to determine the relationship between the shape and the myopic retinochoroidal lesions.

Methods: We studied 488 eyes of 272 patients with high myopia (refractive error ≥-8.00 diopters [D] or axial length >26.5 mm) and 43 emmetropic eyes of 43 controls (refractive error ≤±3 D). An image of the sclera was obtained by a swept-source OCT prototype instrument that uses a wavelength sweeping laser centered on 1 µm wavelength with an A-scan repetition rate of 100,000 Hz. The scans were 12 mm radial scans centered on the fovea. Seventy eyes were also examined by three-dimensional magnetic resonance imaging (3D MRI) to obtain the contour of the outer surface of the eyes. The main outcome measures, visibility of the entire sclera layer, scleral thickness, scleral contour, and location of the most protruded point of the globe, were obtained by swept-source OCT and 3D MRI.

Results: The entire thickness of the sclera was observed in 278 of 488 (57.0%) highly myopic eyes, but the outer border was not observed in any of the emmetropic eyes. The mean subfoveal scleral thickness was 227.9 ± 82.0 µm in the highly myopic eyes. The sclera was thickest at 3000 µm nasal to the fovea. The curvatures of the inner scleral surface of highly myopic eyes could be divided into curvatures that sloped toward the optic nerve, those that were symmetrical and centered on the fovea, those that were asymmetrical, and those that were irregular. Patients with irregular curvature were significantly older and had significantly longer axial lengths than those with other curvatures. Myopic fundus lesions were present significantly more frequently in the eyes with irregular curvature. All of the eyes whose scleral curvature sloped toward the optic nerve had nasally distorted shape in the 3D MRI images, and all eyes with temporally dislocated shape had irregular curvature.

Conclusions: In vivo evaluations of the sclera in highly myopic eyes by swept-source OCT can provide important information on deformations of the sclera and how such deformities are related to myopic fundus lesions.

Significance: The combination of deep penetration and clarity at all depths provided by the SS-OCT prototype allows reconstruction of the sclera profile of myopic eyes.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2127101

Ohno-Matsui K, Akiba M, Moriyama M, Ishibashi T, Hirakata A, Tokoro T. Intrachoroidal cavitation in macular area of eyes with pathologic myopia. American Journal of Ophthalmology. 2012 Aug;154(2):382-93.

Purpose: To determine the incidence and characteristics of intrachoroidal cavitations in the macular area of eyes with high myopia.
Design: Prospective, noninterventional case series.
Methods: We evaluated 56 eyes of 44 patients with pathologic myopia (myopic spherical equivalent >8 diopters) and with patchy chorioretinal atrophy using a swept-source optical coherence tomographic (OCT) system with a center wavelength of 1050 nm. We focused on the changes in the scleral curvature in the area of patchy atrophy. The relationship of the macular intrachoroidal cavitation and retinoschisis was also analyzed. Sixty-eight consecutive patients with pathologic myopia but without patchy atrophy were analyzed as controls.
Results: In 31 of 56 eyes (55.4%) with patchy atrophy, the swept-source OCT images showed that the sclera was bowed posteriorly in and around the patchy atrophy compared to neighboring sclera, whereas none of the 68 patients without patchy atrophy showed this finding. Macular intrachoroidal cavitation had OCT features similar to peripapillary intrachoroidal cavitation; the choroid in the macular intrachoroidal cavitation area appeared thickened and the retina was caved into the cavitation. There was a direct communication between the vitreous and intrachoroidal cavitation in 3 eyes. Retinoschisis was observed significantly more frequently in or around the patchy atrophy in eyes with macular intrachoroidal cavitation than in those without cavitation.
Conclusions: These findings suggest that patchy atrophy affects the scleral contour within posterior staphyloma beyond the funduscopically identified patchy atrophy by macular intrachoroidal cavitation. Such deformation of sclera may facilitate the development of retinoschisis in and around the patchy atrophy.

Significance: This study uses the ability of SS-OCT prototype (Topcon) to provide higher detail of chorioretinal changes in a highly myopic population.

Link: http://www.sciencedirect.com/science/article/pii/S0002939412001067

Ohno-Matsui K, Akiba M, Moriyama M, Shimada N, Ishibashi T, Tokoro T, et al. Acquired optic nerve and peripapillary pits in pathologic myopia. Ophthalmology. 2012 Aug;119(8):1685-92.

Purpose: To examine the incidence and characteristics of pit-like structures around the optic disc and myopic conus in eyes with high myopia.
Design: Prospective, observational case series.
Participants: We evaluated 198 eyes of 119 patients with pathologic myopia (spherical equivalent >-8 diopters [D]). We also evaluated 32 eyes of 32 subjects with emmetropia (refractive error ≤±3 D) as controls.
Methods: The papillary and peripapillary areas were examined with a prototype swept-source optical coherence tomography (OCT) system with a center wavelength of 1050 nm. We studied the structural characteristics of pit-like changes.
Main Outcome Measures: The incidence and characteristics of the optic nerve (ON) pits in eyes with high myopia.
Results: Pit-like clefts were found at the outer border of the ON or within the adjacent scleral crescent in 32 of 198 highly myopic eyes (16.2%) but in none of the emmetropic eyes. The eyes with these pits were more myopic, had significantly longer axial lengths, and had significantly larger optic discs than the highly myopic eyes without pits. The pits were located in the optic disc area (optic disc pits) in 11 of 32 eyes and in the area of the conus outside the optic disc (conus pits) in 22 of 32 eyes. One eye had both optic disc pits and conus pits. The optic disc pits existed in the superior or inferior border of the optic disc. All but 1 eye with conus pits had a type IX staphyloma, and the location of the conus pits were present nasal to the scleral ridge or outside the ridge temporal to the nerve. The optic disc pits were associated with discontinuities of the lamina cribrosa, whereas the conus pits appeared to develop from a scleral stretch-associated schisis or to emissary openings for the short posterior ciliary arteries in the sclera. The nerve fiber tissue overlying the pits was discontinuous at the site of the pits.
Conclusions: Optic nerve pits are common in highly myopic eyes. The ON pits are barely visible ophthalmoscopically but can be demonstrated by using swept-source OCT.

Significance: Swept source OCT is able to capture detailed images of the characteristics of optic disc pits and conus pits in highly myopic eyes. The ability to penetrate deep into the tissue reveals previously unseen features that improve understading of the pathology.

Link: http://www.aaojournal.org/article/S0161-6420(12)00108-X/abstract

Ellabban AA, Tsujikawa A, Matsumoto A, Yamashiro K, Oishi A, Ooto S, et al. Three-dimensional tomographic features of dome-shaped macula by swept-source optical coherence tomography. American Journal of Ophthalmology. 2013 Feb;155(2):320-8 e2.

Purpose: To study the tomographic and pathomorphologic features of dome-shaped maculas with swept-source optical coherence tomography (OCT).
Design: Prospective, cross-sectional study.
Methods: The macular area of 51 highly myopic eyes (35 patients) with dome-shaped maculas was studied with swept-source OCT at 1050 nm. Three-dimensional (3-D) data sets were obtained with raster scanning covering a 12 × 8-mm(2) area; 3-D images of the posterior pole were constructed by auto segmentation of the retinal pigment epithelium (RPE).
Results: In all reconstructed 3-D images of the RPE, 2 outward concavities were seen within the posterior staphyloma and a horizontal ridge was formed between these 2 concavities. In 42 of these eyes, this horizontal ridge was band shaped. The vertical OCT section through the fovea showed a convex configuration of RPE, but the horizontal section showed an almost flat RPE line. In 9 eyes, 3-D images showed a typical dome-shaped convexity within the staphyloma. OCT scans showed no outward protrusions in the external scleral surface, but marked scleral thinning was seen consistent with the 2 outward concavities of the RPE. The sclera of the fovea (518.6 ± 97.6 μm) was significantly thicker than that in all 4 quadrants of the parafoveal area (range, 277.2 to 360.3 μm; $P < .001$).
Conclusions: In highly myopic eyes with a dome-shaped macula, a horizontal ridge is formed within the posterior staphyloma by uneven thinning of the sclera.

Significance: This study uses the longer scan window depth of the SS-OCT prototype (Topcon), a feature of swept source technology. The minimal drop off in signal to noise ratio with depth allows the imaging of highly myopic eyes, revealing previously unseen features in the retina, choroid and sclera thickness over a wide macular area.

Link: **http://www.sciencedirect.com/science/article/pii/S0002939412005788**

Akagi T, Hangai M, Kimura Y, Ikeda HO, Nonaka A, Matsumoto A, et al. Peripapillary scleral deformation and retinal nerve fiber damage in high myopia assessed with swept-source optical coherence tomography. American Journal of Ophthalmology. 2013 May;155(5):927-36.

Purpose: To study peripapillary morphologic changes in highly myopic eyes using swept-source optical coherence tomography at a longer wavelength.
Design: Prospective cross-sectional study.
Methods: Peripapillary regions of 196 eyes of 107 patients with high myopia (refractive error, <-8.0 diopters or axial length, >26.0 mm) were analyzed quantitatively and qualitatively with an swept-source optical coherence tomography prototype system that uses a tunable laser light source operated at a 100,000-Hz A-scan repetition rate in the 1-µm wavelength region. The visual field was evaluated by standard automated perimetry. Area of peripapillary atrophy β and presence of scleral protrusion temporal to the optic disc were assessed.
Results: Peripapillary atrophy β area, but not disc area, was significantly larger in eyes with visual field defect (3.16 ± 2.70 mm(2); range, 0.00 to 12.85 mm(2)) than those without visual field defect (2.31 ± 2.83 mm(2); range, 0.00 to 17.70 mm(2)). Temporal scleral protrusion was detected by color stereo disc photography in 22 (19.5%) of 113 eyes with visual field defect and in 4 (4.8%) of 83 eyes without visual field defect. Scleral bending demonstrated a wide range of angles (mean, 31.0 ± 21.1 degrees; range, 2 to 80 degrees). The angle of scleral bending, but not the distances from scleral bend to disc margin or foveal center, correlated significantly with retinal nerve fiber layer thickness above the bend (r = -0.557, P = .007) and visual field defect severity (r = -0.445, P = .038).
Conclusions: Swept-source optical coherence tomography visualizes peripapillary deep structures in high myopia. Some cases of high myopia may be affected by direct scleral compression or stretching at the peripapillary region.

Significance: This study uses the swept source advantage of higher sensitivity with tissue depth, to investigate peripapillary scleral structures, revealing fine features that may help to explain further pathological changes associated with myopia.

Link: http://www.sciencedirect.com/science/article/pii/S0002939412008902

Ohno-Matsui K, Shimada N, Akiba M, Moriyama M, Ishibashi T, Tokoro T. Characteristics of intrachoroidal cavitation located temporal to optic disc in highly myopic eyes. Eye (Lond). 2013 May;27(5):630-8.

Purpose: To investigate the anatomic characteristics of eyes with pathological myopia and peripapillary intrachoroidal cavitation (ICC) located temporal to the optic disc.
Methods: A total of 125 with pathologic myopia were scanned with swept-source optical coherence tomography (OCT). Temporal ICC was defined as ICC located temporal to the optic disc seen in horizontal OCT section through the optic disc center. Definition of pathologic myopia was refractive error >8.00 diopters (D) or an axial length >26.5 mm.
Results: In all, 17 eyes of 16 patients had temporal ICC. All of the eyes had temporal or temporally wider annular conus. The ICC was observed temporal to the optic disc in 15 of 17 eyes, and 2 of the remaining eyes also had inferior ICC. Even in the two eyes with both temporal and inferior ICC, the temporal ICC was much wider than the inferior ICC. Inner retinal defect at the border of conus and temporal ICC was detected in two eyes. The temporal ICC was extensive in the posterior fundus with the average width of 1467.8 ± 1328.1 µm (range; 442-6200 µm) in a horizontal section. In two eyes, the temporal ICC extended beyond the central fovea.
Conclusions: Peripapillary ICC can develop temporal to the optic disc without involving the area inferior to optic disc in highly myopic eyes. Temporal ICC appeared much wider than inferior ICC, which is usually restricted to the area around the optic disc. The possible reasons why ICC develops in temporal to the optic disc are presented.

Significance This study reports the superior ability of swept source OCT to image myopic eyes. The wide scan window, maintaining clarity with depth, allows clear imaging of eyes with important pathological features at a range of depths.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3650268/

Pedinielli A, Souied EH, Perrenoud F, Leveziel N, Caillaux V, Querques G. In vivo visualization of perforating vessels and focal scleral ectasia in pathological myopia. Investigative Ophthalmology and Vision Science. 2013 Nov;54(12):7637-43.

Purpose: To describe focal scleral ectasia in areas of macular/perimacular patchy chorioretinal atrophy secondary to pathologic myopia.
Methods: Thirty-nine consecutive patients with pathologic myopia and chorioretinal atrophy in at least one eye, with and without focal scleral ectasia, were analyzed by infrared reflectance (IR) and/or multicolor imaging, enhanced depth imaging optical coherence tomography (EDI-OCT) (39 patients, 78 eyes), and swept source (SS)-OCT (13 out of 39 patients, 26 eyes) cross-sectional scan.
Results: Focal scleral ectasia was found in 12 out of 68 eyes (11 out of 39 consecutive patients, 27 females/12 males; mean age 65.7 ± 11.9 years) with macular/perimacular patchy chorioretinal atrophy, and was always observed inferior or temporal to the macula (mean 1.25 ± 0.38/eye). Focal scleral ectasia, appearing on fundus examination as a deep dark round/oval lesion with well-defined borders, was characterized on EDI-OCT and SS-OCT by an abrupt posterior bow of the sclera with different degrees of scleral schisis on its borders. The retinal pigment epithelium and the choroid were absent in all lesions. IR reflectance and multicolor imaging showed large vessels that seem to emerge from the focal scleral ectasia, and crossing the area of patchy atrophy. EDI-OCT and SS-OCT revealed retrobulbar vessels perforating the sclera at the borders/bottom of the abrupt posterior bow of the sclera (i.e., focal scleral ectasia) and running through the superficial scleral thickness for the whole extension of the atrophic area.
Conclusions: We showed that perforating vessels are localized at the border/bottom of focal scleral ectasia in pathologic myopia.

Significance: SS OCT and SD-OCT with enhanced depth imaging were both able to investigate sclera ectasia, however the deep penetration of SS-OCT provided additional information of retrobulbar vessels entering the sclera. This paper provides a couple of interesting comparisons of the same myopic feature, with SS-OCT clearly providing greater detail than SD-OCT with EDI.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2127896

Itakura H, Kishi S, Li D, Nitta K, Akiyama H. Vitreous changes in high myopia observed by swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2014 Mar;55(3):1447-52.

Purpose: To observe vitreous changes in high myopia using swept-source optical coherence tomography (SS-OCT).

Methods: We performed slit-lamp biomicroscopy and SS-OCT in the highly myopic right eyes of 151 patients (mean age, 52.7 years; mean refraction, -11.4 diopters [D]) and the right eyes with no myopia of 363 healthy control volunteers (mean age, 52.8 years; mean refraction, -1.4 D). To estimate the sizes of the posterior precortical vitreous pockets (PPVPs), we measured the height between the fovea and the anterior border of the PPVPs.

Results: Patients with partial posterior vitreous detachments (PVDs) around the macula and complete PVDs in high myopia were significantly ($P < 0.0001$) younger (47.1 ± 14.1 and 61.2 ± 12.0 years, respectively) than controls (59.0 ± 9.6 and 69.7 ± 6.6 years). The PPVPs with no PVDs were significantly ($P < 0.001$) higher in 32 eyes with high myopia (984 ± 292 µm) than 164 controls (553 ± 166 µm). After a complete PVD with a Weiss ring developed, the vitreous cortex was on the macula in 40.5% of the eyes with high myopia, which differed significantly ($P < 0.0001$) from the 8.7% of the controls. Myopic foveoschisis was present in 14 (9.3%) of 151 eyes. In eyes with foveoschisis, three (21.4%) eyes had partial PVDs and 11 (78.6%) eyes had complete PVDs; there was no residual cortex in 8 (72.7%) of 11 eyes with complete PVDs.

Conclusions: Highly myopic eyes may have larger PPVPs than normal eyes. Partial PVDs around the macula and complete PVDs occur at younger ages. The vitreous cortex more frequently remains on the macula after development of complete PVDs in highly myopic eyes.

Significance: This report describes for the first time the precursor stages in PVD, made possible by swept source OCT imaging of the vitreous. The high contrast and longer scan window depth allow the visualization of the posterior vitreous.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2189932

Swept Source Optical Coherence Tomography –

Glaucoma Application

Usui S, Ikuno Y, Miki A, Matsushita K, Yasuno Y, Nishida K. Evaluation of the choroidal thickness using high-penetration optical coherence tomography with long wavelength in highly myopic normal-tension glaucoma. American Journal of Ophthalmology. 2012 Jan;153(1):10-6 e1.

Purpose: To evaluate the choroidal thickness by high-penetration optical coherence tomography (OCT) using long wavelength in highly myopic normal-tension glaucoma (NTG).
Design: Cross-sectional retrospective study.
Settings: Institutional.
Participants: Twelve eyes from 8 patients under 45 years old, diagnosed as NTG without any other ocular diseases, spherical equivalent refractive error between -6 and -12 diopters, and axial length greater than 26.5 mm; and 12 eyes of matched healthy volunteers.
Iintervention: Choroid was imaged with prototype high-penetration OCT and its thickness was measured.
Main Outcome Measures: Choroidal thickness at the fovea and 5 locations: 2 mm superior, temporal, and inferior to the center of the optic nerve head, and 2 mm superior (superotemporal) and 2 mm inferior (inferotemporal) to the temporal location.
Results: Overall, the choroidal thickness in the NTG group was approximately 50% that in controls. Mean choroidal thickness in the NTG group was significantly thinner in the control group at the fovea (166 vs 276 µm, $P < .001$), superior (172 vs 241 µm, $P < 0.05$), superotemporal (161 vs 244 µm, $P < .01$), temporal (110 vs 161 µm, $P < .01$), and inferotemporal (115 vs 159 µm, $P < .05$) to the optic nerve head. Stepwise analysis disclosed that the foveal choroidal thickness is the most influential factor on the occurrence of NTG ($P < .0001$, $R(2) = 0.4$).
Conclusions: Choroidal thickness in highly myopic NTG is significantly thinner than in controls, at least in some specific locations. Choroidal thinning is somehow related with highly myopic NTG and may be a useful diagnostic parameter for myopic NTG.

Significance: Significant choroidal thinning is present in myopic individuals with normal tension glaucoma compared to age, axial length and refractive error matched controls. The deep penetration of SS-OCT allows accurate measurement of choroid thickness in the foveal area and around the optic nerve.

Link: http://www.ajo.com/article/S0002-9394(11)00464-8/abstract

Zhang C, Tatham AJ, Medeiros FA, Zangwill LM, Yang Z, Weinreb RN. Assessment of choroidal thickness in healthy and glaucomatous eyes using swept source optical coherence tomography. PLoS One. 2014;9(10):e109683.

Purpose: To evaluate choroidal thickness (CT) in healthy and glaucomatous eyes using Swept Source Optical Coherence Tomography (SS-OCT).
Methods: A cross-sectional observational study of 216 eyes of 140 subjects with glaucoma and 106 eyes of 67 healthy subjects enrolled in the Diagnostic Innovations in Glaucoma Study. CT was assessed from wide-field (12×9 mm) SS-OCT scans. The association between CT and potential confounding variables including age, gender, axial length, intraocular pressure, central corneal thickness and ocular perfusion pressure was examined using univariable and multivariable regression analyses.
Results: Overall CT was thinner in glaucomatous eyes with a mean (± standard deviation) of 157.7±48.5 µm in glaucoma compared to 179.9±36.1 µm in healthy eyes (P<0.001). The choroid was thinner in both the peripapillary and macular regions in glaucoma compared to controls. Mean peripapillary CT was 154.1±44.1 µm and 134.0±56.9 µm (P<0.001) and macular CT 199.3±46.1 µm and 176.2±57.5 µm (P<0.001) for healthy and glaucomatous eyes respectively. However, older age (P<0.001) and longer axial length (P<0.001) were also associated with thinner choroid and when differences in age and axial length between glaucomatous and healthy subjects were accounted for, glaucoma was not significantly associated with CT. There was also no association between glaucoma severity and CT.
Conclusions: Glaucoma was not associated with CT measured using SS-OCT; however, older age and longer axial length were associated with thinner choroid so should be considered when interpreting CT measurements.

Significance: The swept source DRI OCT-1 Atlantis using wide-field scanning allows imaging of the macular and the peripapillary region in a single scan, enabling measurements of the retina and choroid over a wider area than previously studied.

Link: **http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4190357/**

Takayama K, Hangai M, Kimura Y, Morooka S, Nukada M, Akagi T, et al. Three-dimensional imaging of lamina cribrosa defects in glaucoma using swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2013 Jul;54(7):4798-807.

Purpose: To visualize lamina cribrosa defects using three-dimensional (3D) swept-source optical coherence tomography (SS-OCT), and to determine the factors associated with this feature.
Methods: All subjects were examined using an SS-OCT prototype system, which uses a tunable laser as a light source, operated at 100,000 Hz A-scan repetition rate in the 1050-nm wavelength. A 3D raster scan protocol consisting of 256×256 A-scans was acquired over a square area of 3 mm×3 mm centered on the optic disc. En face sectioned volume and serial en face images and orthogonal (horizontal and vertical) serial B-scans were evaluated.
Results: A total of 182 eyes of 111 patients with glaucoma and 29 healthy eyes of 26 subjects were included. Twenty full-thickness focal lamina cribrosa defects were found in 12 (6.6%) of 182 eyes with glaucoma, whereas no lamina defects were found in healthy eyes. Nine eyes (75.0%) showed 15 full-thickness lamina cribrosa defects near the margin of the lamina cribrosa, and 3 eyes showed 4 lamina defects at the margin, as if detached from the sclera. Focal lamina cribrosa defects corresponded with neuroretinal rim thinning, concurrent or previous disc hemorrhages, abnormal circumpapillary retinal nerve fiber layer thickness, and visual field defects. The presence of lamina cribrosa defects was significantly associated with longer axial length and disc hemorrhages (P=0.033 and 0.024, respectively).
Conclusions: 3D SS-OCT imaging allows visualization of the lamina cribrosa defects, which may be more prevalent in eyes with longer axial length and related to disc hemorrhages.

Significance: The 3D imaging of lamina cribosa obtained with SS-OCT is a useful method for detection of focal full-thicknesss lamina cribosa defects; the clarity of detail helps to differentiate between real lamina cribosa defects and vascular artifacts.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2128343

Kimura Y, Akagi T, Hangai M, Takayama K, Hasegawa T, Suda K, et al. Lamina cribrosa defects and optic disc morphology in primary open angle glaucoma with high myopia. PLoS One. 2014;9(12):e115313.

Purpose: To investigate whether lamina cribrosa (LC) defects are associated with optic disc morphology in primary open angle glaucoma (POAG) eyes with high myopia.
Methods: A total of 129 POAG patients and 55 age-matched control subjects with high myopia were evaluated. Three-dimensional scan images obtained by swept source optical coherence tomography were used to detect LC defects. Radial B-scans and infrared images obtained by spectral domain optical coherence tomography were used to measure β-peripapillary atrophy (PPA) lengths with and without Bruch's membrane (BM) (temporal, nasal, superior, and inferior), tilt angle (vertical and horizontal), and disc diameter (transverse and longitudinal). Peripapillary intrachoroidal cavitations (PICCs), disc area, ovality index, and cyclotorsion of the optic disc were analyzed as well.
Results: LC defects were found in 70 of 129 (54.2%) POAG eyes and 1 of 55 (1.8%) control eyes ($P < 0.001$). Age, sex, spherical equivalent, axial length, intraocular pressure, and central corneal thickness were not significantly different among POAG eyes with LC defects, POAG eyes without LC defects, and control eyes. Temporal PPA lengths without BM in all three groups correlated significantly with vertical and horizontal tilt angles, although no PPA length with BM correlated significantly with any tilt angle. PICCs were detected more frequently in POAG eyes with LC defects than those without LC defects ($P = 0.01$) and control eyes ($P = 0.02$). POAG eyes with LC defects showed a smaller ovality index ($P = 0.004$), longer temporal PPA without BM ($P < 0.001$), and larger vertical/horizontal tilt angles (vertical, $P < 0.001$; horizontal, $P = 0.01$), and transverse diameter ($P = 0.01$). In multivariate analysis for the presence of LC defects, presence of POAG ($P < 0.001$) and vertical tilt angle ($P < 0.001$) were identified as significant.
Conclusions: The presence of LC defects was associated with myopic optic disc morphology in POAG eyes with high myopia.

Significance: The lamina cribosa images obtained using swept source OCT provides important additional information in glaucoma patients.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4274005/

Lee KM, Kim TW, Weinreb RN, Lee EJ, Girard MJ, Mari JM. Anterior lamina cribrosa insertion in primary open-angle glaucoma patients and healthy subjects. PLoS One. 2014;9(12):e114935.

Purpose: To determine using swept-source optical coherence tomography (SS-OCT) whether there are differences in the location of the anterior lamina cribrosa insertion (ALI) in primary open-angle glaucoma (POAG) patients and healthy subjects.
Methods: Fifty three eyes from 53 patients with POAG, and 53 eyes from 53 age-matched healthy subjects were included prospectively in Seoul National University Bundang Hospital. Twelve radial line B-scans centered on the optic disc in every half-clock-hour meridian were acquired using SS-OCT. The ALI position was assessed by measuring two parameters: (1) ALI distance (ALID)--the distance from the anterior scleral canal opening (ASCO) to the ALI; and (2) marginal anterior lamina cribrosa surface depth (mALCSD)--the perpendicular distance from the ASCO plane to the anterior lamina cribrosa surface. These parameters were compared between the two groups for each meridian.
Results: Both ALID (256 ± 54 vs. 209 ± 37 µm, mean ± SD, $p < 0.001$) and mALCSD (232 ± 63 vs. 187 ± 40 µm, $p < 0.001$) were significantly greater in the POAG group than in the normal group. The largest difference was observed at the 6.5 o'clock and 11.5 o'clock meridians for both ALID and mALCSD. Multiple regression analysis revealed a negative correlation between age and both ALID and mALCSD in the control group, and a negative correlation between mean deviation of the visual field test and both ALID and mALCSD in the POAG group.
Conclusions: The ALI was displaced posteriorly in eyes with POAG compared to those of healthy controls. This finding suggests that the posteriorly located lamina cribrosa insertion is an important component of glaucomatous optic nerve excavation.

Significance: The enhanced penetration properties of swept source OCT were used to analyse the anterior lamina cribosa insertion and this is correlated with visual field defect. This emphasizes the importance of OCT findings in glaucoma management.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4273977/

Lopilly Park HY, Lee NY, Choi JA, Park CK. Measurement of scleral thickness using swept-source optical coherence tomography in patients with open-angle glaucoma and myopia. American Journal of Ophthalmology. 2014 Apr;157(4):876-84.

Purpose: To use swept-source optical coherence tomography (OCT) to image the posterior sclera at the posterior pole and around the optic nerve head (ONH) and measure the subfoveal scleral thickness and laminar thickness to evaluate the relationship between the measured thicknesses and ocular parameters.
Design: Prospective, cross-sectional design.
Methods: The study included 103 patients with glaucoma and 43 controls with axial lengths more than 26 mm. Swept-source OCT images were obtained to capture the subfoveal and ONH regions. Subfoveal scleral thickness and laminar thickness were measured from obtained B-scan images. To verify the reproducibility of the measurement, intraclass correlation coefficients were calculated from selected B-scans. Scleral and laminar thicknesses in patients with normal-tension glaucoma (NTG) was compared with that in patients with primary open-angle glaucoma (POAG). A Pearson correlation was calculated to assess the relationships of scleral and laminar thicknesses with ocular parameters.
Results: Posterior scleral thickness could be measured in 68.4% of patients, and laminar thickness could be measured in 88.6% by using swept-source OCT. Interobserver and intraobserver measurement reproducibility was moderate to excellent. The subfoveal scleral thickness was 670.84 ± 160.60 µm in the POAG group and 496.55 ± 115.20 µm in the NTG group; a significant difference between the groups was observed. Subfoveal scleral thickness ($r = -0.677$, $P < 0.001$) was negatively correlated with axial length only in patients with NTG, not in patients with POAG.
Conclusions: Swept-source OCT detected differences in the thicknesses of the posterior sclera between eyes with NTG and eyes with POAG. Subfoveal scleral thickness was negatively correlated with axial length only in eyes with NTG.

Significance: Differences in the thickness of the posterior scleral between POAG and NTG eyes can be detected when using the deep penetration of swept source OCT to image the sclera.

Link: http://www.sciencedirect.com/science/article/pii/S0002939414000130 /

Nakakura S, Yamamoto M, Terao E, Nagasawa T, Tabuchi H, Kiuchi Y. The whole macular choroidal thickness in subjects with primary open angle glaucoma. PLoS One. 2014;9(10):e110265.

Purpose: We investigated the whole macular choroidal thickness in subjects with glaucoma in order to evaluate the effects of glaucoma and glaucoma visual field damage on the choroidal thickness.
Subjects and Methods: We examined 40 primary open angle glaucoma patients with only superior visual field defects and 48 normal controls. The macular choroidal thickness was measured using swept-source optical coherence tomography according to the three-dimensional raster scan protocol (6×6 mm). We used the choroidal thickness within a 1.0-mm circle measured on ETDRS grids as the central sector and then used a 6×6 rectangular grid to divide the area into six sectors.
Results: No significant differences were found in the choroidal thickness values between the glaucoma and normal subjects in any of the sectors after adjusting for the age and axial length (all P>0.4, ANCOVA). According to a stepwise analysis of the glaucoma subjects performed using the parameters of age, axial length, central corneal thickness and mean deviation (MD value) obtained by static perimetry, age was the most predictive and significant factor in all sectors (coefficient =-3.091 to -4.091 and F value=15.629 to 22.245), followed by axial length (coefficient=-10.428 to -23.458 and F value=2.454 to 6.369). The central corneal thickness and MD values were not significant predictive factors in any of the sectors. No significant predictive factors were found for the differences in the choroidal thickness values observed between the superior and inferior field sectors.
Conclusions: Neither the glaucoma-related visual field damage nor glaucoma itself have any apparent associations with the whole macular choroidal thickness.

Significance: The DRI OCT-1 Atlantis provides a complete and detailed profile of choroidal thickness allowing a comprehensive comparison between regions, which is an advantage over other OCT systems that use averaging algorithms to determine the choroid thickness.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4211920/

Yoshikawa M, Akagi T, Hangai M, Ohashi-Ikeda H, Takayama K, Morooka S, et al. Alterations in the neural and connective tissue components of glaucomatous cupping after glaucoma surgery using swept-source optical coherence tomography. Investigative Ophthalmology and Vision Science. 2014 Jan; 55(1):477-84.

Purpose: To visualize changes in deep optic nerve head (ONH) structures following glaucoma surgery using (3-dimensional [3D]) swept-source optical coherence tomography (SS-OCT) and to determine the clinical and structural factors associated with postoperative lamina cribrosa (LC) and prelaminar neural tissue (PLT) changes.
Methods: In this prospective observational case series, SS-OCT thin-sliced datasets of the ONH covering a 3- × 3-mm area comprised of 256 B-scans (interval between scans = ∼12 μm) were obtained before and 3 months after the surgery and evaluated in 73 eyes of 73 patients with glaucoma. Bruch's membrane opening (BMO) and anterior LC boundary were manually delineated by two methods; one in every four B-scans (64 B-scans per eye) and 15 equally spaced horizontal B-scans in BMO area, excluding both ends (interval between scans = 96-120 μm). After former delineation, the point with maximum LC depth among 64 B-scans was automatically calculated, and LC depth and PLT thickness were averaged among 5 points adding 4 points 100 μm apart from this point vertically and horizontally. Associations between the percent change in LC depth and other clinical and structural parameters were tested for statistical analysis.
Results: Lamina cribrosa depth and axial length significantly decreased and PLT thickness significantly increased after surgery. The percent change of maximum LC depth correlated significantly with the percent change of IOP (P = 0.008), baseline LC depth (P = 0.032), and visual field mean deviation (P = 0.035; at the point with maximum LC depth), while the percent change of axial length correlated with IOP reduction (P = 0.002) but not with visual field mean deviation.
Conclusions: Swept-source optical coherence tomography enables 3D analysis of deep ONH structures, and the change in LC depth after glaucoma surgery, both of which have associations with IOP change and the severity of glaucomatous optic neuropathy.

Significance: Application of thin-sliced image technology allows for clear visualization of deep structures within, and measurement of the ONH, which can be used as a tool for monitoring glaucoma patients.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2128729

Kwun Y, Han JC, Kee C. Comparison of lamina cribrosa thickness in normal tension glaucoma patients with unilateral visual field defect. American Journal of Ophthalmology. 2015 Mar;159(3):512-8 e1.

Purpose: To compare the lamina cribrosa thickness, measured by swept-source optical coherence tomography (SS OCT), between each eye of normal tension glaucoma (NTG) patients with unilateral visual field (VF) defect and to investigate the correlation between lamina cribrosa thickness and VF loss.
Design: Prospective, cross-sectional study.
Methods: Optic nerve heads were scanned using SS OCT, and laminar thickness was measured on mid-superior, central, and mid-inferior regions of vertical midline of the optic disc. The inter-eye differences of lamina cribrosa thickness in NTG patients with unilateral VF defect and the intra-eye difference of lamina cribrosa thickness in VF-affected eyes were analyzed using the paired t test. We evaluated the correlation between lamina cribrosa thickness and mean deviation, measured using standard automated perimetry, in NTG patients.
Results: This study included 102 eyes in 51 NTG patients with unilateral VF defect and 47 eyes in 47 normal subjects without glaucomatous change in either eye. The mean lamina cribrosa thickness of normal fellow eyes was thicker than VF-affected eyes in NTG patients ($P < .001$), but thinner than normal subject eyes ($P < .001$). Within VF-affected eyes, lamina cribrosa thickness of regions correlated with visual field defect was thinner than horizontally contralateral locations ($P < .001$). The mean deviation was statistically correlated with inter-eye difference of lamina cribrosa thickness in NTG patients ($n = 51$; $r(2) = 0.12$; $P = .01$).
Conclusions: The lamina cribrosa was thinner in VF-unaffected eyes of NTG patients than in normal subject eyes, in VF-affected eyes than in normal fellow eyes of NTG patients, and in regions correlated with visual field loss than in horizontally contralateral ones in VF-affected eyes.

Significance: The ability of swept source OCT to visualize lamina cribosa thickness and detect subtle differences between eyes with and without visual field loss, makes it a useful tool for assessing NTG.

Link: http://www.sciencedirect.com/science/article/pii/S000293941400779X

Omodaka K, Horii T, Takahashi S, Kikawa T, Matsumoto A, Shiga Y, et al. 3D evaluation of the lamina cribrosa with swept-source optical coherence tomography in normal tension glaucoma. PLoS One. 2015;10(4):e0122347.

Purpose: Although the lamina cribrosa (LC) is the primary site of axonal damage in glaucoma, adequate methods to image and measure it are currently lacking. Here, we describe a noninvasive, in vivo method of evaluating the LC, based on swept-source optical coherence tomography (SS-OCT), and determine this method's ability to quantify LC thickness.
Methods: This study comprised 54 eyes, including normal (n = 18), preperimetric glaucoma (PPG; n = 18), and normal tension glaucoma (NTG; n = 18) eyes. We used SS-OCT to obtain 3 x 3 mm cube scans of an area centered on the optic disc, and then synchronized reconstructed B- and en-face images from this data. We identified the LC in these B-scan images by marking the visible borders of the LC pores. We marked points on the anterior and posterior borders of the LC in 12 B-scan images in order to create a skeleton model of the LC. Finally, we used B-spline interpolation to form a 3D model of the LC, including only reliably measured scan areas. We calculated the average LC thickness (avgLCT) in this model and used Spearman's rank correlation coefficient to compare it with circumpapillary retinal nerve fiber layer thickness (cpRNFLT).
Results: We found that the correlation coefficient of avgLCT and cpRNFLT was 0.64 ($p < 0.01$). The coefficient of variation for avgLCT was 5.1%. AvgLCT differed significantly in the groups (normal: 282.6 ± 20.6 µm, PPG: 261.4 ± 15.8 µm, NTG: 232.6 ± 33.3 µm). The normal, PPG and NTG groups did not significantly differ in age, sex, refractive error or intraocular pressure (IOP), although the normal and NTG groups differed significantly in cpRNFLT and Humphrey field analyzer measurements of mean deviation.
Conclusion: Thus, our results indicate that the parameters of our newly developed method of measuring LC thickness with SS-OCT may provide useful and important data for glaucoma diagnosis and research.

Significance: Software using DRI OCT-1 Atlantis images and consisting of the synchronization of B-scan and en face images is used to investigate the thickness of lamina cribosa with high reproducibility. This allows the 3D visualization of the lamina cribosa which may provide a useful tool in the diagnosis and management of glaucoma.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4398555/

Omodaka K, Yokoyama Y, Shiga Y, Inoue M, Takahashi S, Tsuda S, et al. Topographical correlation between macular layer thickness and clockwise circumpapillary retinal nerve fiber layer sectors in patients with normal tension glaucoma. Current Eye Research. 2015 Jul;40(7):744-51.

Purpose: To define topographical areas of the macula in optical coherence tomography (OCT) scans by identifying regions in which macular retinal nerve fiber layer (mRNFL) and ganglion cell-inner plexiform layer (mGCL + IPL) thickness was highly correlated with clockwise circumpapillary RNFL (cpRNFL) thickness in patients with normal tension glaucoma (NTG).
Methods: This study included 101 eyes of 101 patients with mild or moderate NTG. CpRNFL, mRNFL, and mGCL + IPL thickness were assessed with spectral-domain OCT (3D OCT-2000). The region of interest (6 × 6 mm square) was centered on the fovea and layer thickness was measured at each point on a 10 × 10 grid. Spearman's rank correlation coefficient was determined between each temporal clockwise sector (7, 8, 9, 10, 11 o'clock) of the cpRNFL and each grid point in the mRNFL and mGCL + IPL. Grid points were defined as correlated to specific clockwise sectors when the correlation coefficient was more than 0.4. To validate the areas comprised by these points, they were superimposed on a swept-source OCT image (12 × 9 mm, EnView software, Topcon) showing the anatomical trajectory of nerve fiber defects.
Results: Macular areas with a high correlation coefficient ($r \geq 0.4$, $p < 0.05$) to clockwise cpRNFL were identified. The number of grid points in the mRNFL and mGCL + IPL correlated to specific clockwise cpRNFL sectors was, respectively, 40 and 18 (7 o'clock), 41 and 22 (8), 33 and 44 (9), 39 and 39 (10), and 18 and 19 (11) ($r = 0.40$-0.79). Interestingly, the distribution of mRNFL sectors closely matched the RNFL defects in the OCT image, although the mGCL + IPL sectors differed and were closer to the fovea than the mRNFL sectors.
Conclusion: The identification of these topographical macular areas, and the different layouts in the mRNFL and the mGCL + IPL, may increase the accuracy of clinical research on NTG.

Relevance: ★★★

Significance: Swept source enface images of the nerve fiber layer identifying defects, showed high correlation with conventional measurements of mRNFL thickness made with SD-OCT.

Link: http://informahealthcare.com/doi/abs/10.3109/02713683.2014.956371

Yang Z, Tatham AJ, Weinreb RN, Medeiros FA, Liu T, Zangwill LM. Diagnostic ability of macular ganglion cell inner plexiform layer measurements in glaucoma using swept source and spectral domain optical coherence tomography. PLoS One. 2015;10(5):e0125957.

Purpose: To evaluate the diagnostic ability of macular ganglion cell and inner plexiform layer measurements in glaucoma, obtained using swept source (SS) and spectral domain (SD) optical coherence tomography (OCT) and to compare to circumpapillary retinal nerve fiber layer (cpRNFL) thickness measurements.
Methods: The study included 106 glaucomatous eyes of 80 subjects and 41 eyes of 22 healthy subjects from the Diagnostic Innovations in Glaucoma Study. Macular ganglion cell and inner plexiform layer (mGCIPL), macular ganglion cell complex (mGCC) and cpRNFL thickness were assessed using SS-OCT and SD-OCT, and area under the receiver operating characteristic curves (AUCs) were calculated to determine ability to differentiate glaucomatous and healthy eyes and between early glaucomatous and healthy eyes.
Results: Mean (± standard deviation) mGCIPL and mGCC thickness were thinner in both healthy and glaucomatous eyes using SS-OCT compared to using SD-OCT. Fixed and proportional biases were detected between SS-OCT and SD-OCT measures. Diagnostic accuracy (AUCs) for differentiating between healthy and glaucomatous eyes for average and sectoral mGCIPL was similar in SS-OCT (0.65 to 0.81) and SD-OCT (0.63 to 0.83). AUCs for average cpRNFL acquired using SS-OCT and SD-OCT tended to be higher (0.83 and 0.85, respectively) than for average mGCC (0.82 and 0.78, respectively), and mGCIPL (0.73 and 0.75, respectively) but these differences did not consistently reach statistical significance. Minimum SD-OCT mGCIPL and mGCC thickness (unavailable in SS-OCT) had the highest AUC (0.86) among macular measurements.
Conclusion: Assessment of mGCIPL thickness using SS-OCT or SD-OCT is useful for detecting glaucomatous damage, but measurements are not interchangeable for patient management decisions. Diagnostic accuracies of mGCIPL and mGCC from both SS-OCT and SD-OCT were similar to that of cpRNFL for glaucoma detection.

Significance: The DRI OCT-1 Atlantis is a useful and comparable technique to conventional SD-OCT (Cirrus) to assist in the differentiation of glaucomatous and healthy eyes. As with SD-OCT, measurements between different instruments are not interchangeable and patients should ideally be followed up on one instrument.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4433247/

Yang Z, Tatham AJ, Zangwill LM, Weinreb RN, Zhang C, Medeiros FA. Diagnostic ability of retinal nerve fiber layer imaging by swept-source optical coherence tomography in glaucoma. American Journal of Ophthalmology. 2015 Jan;159(1):193-201.

Purpose: To evaluate the diagnostic accuracies of swept source optical coherence tomography (OCT) wide-angle and peripapillary retinal nerve fiber layer (RNFL) thickness measurements for glaucoma detection.
Design: Cross-sectional case-control study.
Methods: In this study we enrolled 144 glaucomatous eyes of 106 subjects and 66 eyes of 42 healthy subjects from the Diagnostic Innovations in Glaucoma Study. Glaucoma was defined by the presence of repeatable abnormal standard automated perimetry results and/or progressive glaucomatous optic disc change on masked grading of stereophotographs. Wide-angle and peripapillary RNFL thicknesses were assessed using swept-source OCT. Peripapillary RNFL thickness was also evaluated using spectral-domain OCT. Areas under the receiver operating characteristic (ROC) curves were calculated to evaluate the ability of the different swept-source OCT and spectral-domain OCT parameters to discriminate between glaucomatous and healthy eyes.
Results: Mean (± standard deviation) average spectral-domain OCT wide-angle RNFL thicknesses were 50.5 ± 5.8 µm and 35.0 ± 9.6 µm in healthy and glaucomatous eyes, respectively ($P < 0.001$). Corresponding values for swept-source OCT peripapillary RNFL thicknesses were 103.5 ± 12.3 µm and 72.9 ± 16.5 µm, respectively ($P < 0.001$). Areas under the ROC curves of swept-source OCT wide-angle and peripapillary RNFL thickness were 0.88 and 0.89, respectively. Swept-source OCT performed similar to average peripapillary RNFL thickness obtained by spectral-domain OCT (area under the ROC curve of 0.90).
Conclusion: Swept-source OCT wide-angle and peripapillary RNFL thickness measurements performed well for detecting glaucomatous damage. The diagnostic accuracies of the swept-source OCT and spectral-domain OCT RNFL imaging protocols evaluated in this study were similar.

Significance: Wide-angle peripapillary measurements of RFNL using DRI OCT-1 Atlantis are valuable in detecting glaucomatous damage. The scanning speed of SS-OCT allows the macular and disc areas to be captured in a single scan (12x9mm) without any loss of sampling density. This has significant implications for clinic workflow and patient experience.

Link: http://www.ajo.com/article/S0002-9394(14)00667-9/abstract

Kim YW, Kim DW, Jeoung JW, Kim DM, Park KH. Peripheral lamina cribrosa depth in primary open-angle glaucoma: a swept-source optical coherence tomography study of lamina cribrosa. Eye (London). 2015 Aug 21.

Purpose: To investigate peripheral lamina cribrosa depth (PLCD) and its vertical-horizontal difference in eyes with primary open-angle glaucoma (POAG).
Methods: Patients with POAG (n=90 eyes) and age-matched healthy individuals (n=90 eyes) underwent swept-source optical coherence tomography (SS-OCT) scans centered at the optic discs. The PLCD was defined as the vertical distance between the most peripheral visible end of anterior lamina cribrosa (LC) surface and the reference plane connecting the Bruch's membrane openings. The PLCD in each quadrant region and the vertical-horizontal PLCD difference were compared between the POAG and healthy eyes. The clinical factors associated with increased PLCD were evaluated.
Results: The PLCD was significantly larger in the POAG eyes than the control eyes at the horizontal (P=0.034) and vertical (P=0.001) meridians. The vertical PLCD was significantly larger than the horizontal PLCD, both in the POAG eyes (P<0.001) and in the control eyes (P=0.003). However, the vertical-horizontal PLCD difference was significantly larger in the POAG eyes (47±60 μm) than in the control eyes (18±54 μm, P=0.001). Multivariate regression showed a significant association of male gender (P=0.005), increased baseline IOP (P=0.043), and decreased MD of VF (P=0.025) with increased PLCD.
Conclusions: The peripheral LC was displaced more posteriorly in the POAG eyes compared with the age-matched healthy eyes. In the POAG eyes, the peripheral LC was displaced more posteriorly at the vertical meridian than at the horizontal meridian. The peripheral LC in the vertical meridian might have increased IOP-related strain (deformation) compared with horizontal meridian in glaucomatous eyes.

Significance: Swept source OCT (DRI OCT-1 Atlantis) allows excellent visualization of the peripheral lamina cribosa microstructure, aiding the differentiation between normal and glaucoma subjects.

Link: http://www.nature.com/eye/journal/vaop/ncurrent/full/eye2015162a.html

Lee SH, Lee EJ, Kim TW. Structural Characteristics of the Acquired Optic Disc Pit and the Rate of Progressive Retinal Nerve Fiber Layer Thinning in Primary Open-Angle Glaucoma. JAMA Ophthalmology. 2015 Aug 6.

Importance: The optic disc pit (ODP) has been considered a region of localized susceptibility to the damage of glaucoma.
Objective: To determine whether the rate of retinal nerve fiber layer (RNFL) thinning differs according to the presence andstructural characteristics of an ODP in primary open-angle glaucoma.
Design, Setting, and Participants: We performed a prospective case-control study that included 163 eyes withprimary open-angle glaucoma (83 with an ODP and 80 without an ODP) from Glaucoma Clinic of Seoul National University Bundang Hospital. Participants were enrolled from the ongoing Investigating Glaucoma Progression Study from January 1, 2012, through May 31, 2014. Mean (SD) follow-up was 3.32 (0.49) years (through May 31, 2014). Optic nerve heads underwent swept-source optical coherence tomography (OCT) to determine the presence of focal lamina cribrosa alteration and its structural characteristics. Eyes with and without photographic ODPs and corresponding microscopic laminar alterations were assigned to the ODP and non-ODP groups, respectively. The rates of progressive thinning of global and 6 sectoral spectral-domain OCT RNFL thicknesses were determined by linear regression and compared between the 2 groups. We used a general linear model to determine the factors associated with the rate of RNFL thinning; data obtained from September 21, 2009, through May 31, 2014, were used to calculate the rate of RNFL thinning.
Main Outcomes and Measures: The relationship between the presence and structural characteristics of ODPs and therate of progressive OCT RNFL thinning.
Results: Thinning of the RNFL was faster in the ODP group than in the non-ODP group in the global (mean [SD], -1.44 [1.31] vs -0.93 [1.10] [95% CI, -0.97 to -0.19] µm/y; P = .008), temporoinferior (mean [SD], -4.17 [4.15] vs -1.97 [3.26] [95% CI, -3.36 to -1.04] µm/y; P < .001), and temporal (mean [SD], -1.92 [2.62] vs -0.89 [1.62] [95% CI, -1.70 to -0.35] µm/y; P = .003) sectors. The rate of RNFL thinning was maximum in the temporoinferior sector (mean [SD], -4.17 [4.15] µm/y) and corresponded to the frequency distribution of ODPs. Regression analysis revealed that faster global RNFL thinning was related to a higher untreated intraocular pressure (β = -0.07; 95% CI, -0.11 to -0.03; P = .001), episodes of disc hemorrhage (β = -0.74; 95% CI, -1.79 to 0.31; P = .003), the presence of β-zone parapapillary atrophy (β = -0.47; 95% CI, -1.13 to 0.20; P = .02), and the presence of ODPs (β = -0.41; 95% CI, -1.14 to 0.32; P = .02). The maximum rate of RNFL thinning was associated with higher untreated intraocular pressure (β = -0.24; 95% CI, -0.35 to -0.13; P < .001), disc hemorrhage (β = -1.54; 95% CI, -2.88 to -0.19; P < .001), and the presence (β = -1.04; 95% CI, -2.14 to 0.07; P = .004), far-peripheral location (β = -1.75; 95% CI, -3.05 to -0.46; P = .008), and partial-thickness depth (β = -1.45; 95% CI, -2.75 to -0.16; P = .03) of an ODP.
Conclusions and Relevance: The presence and structural characteristics of ODPs were associated with global and focal progression as assessed by the rate of OCT RNFL thinning. The assessment of ODP structure using swept-source OCT may help to predict the location of future progression.

Significance: Swept source OCT (DRI OCT-1 Atlantis in this paper) allows good visualization of the peripheral lamina cribosa structure due to deeper penetration of the tissues and limited reduction in signal to noise ration with increasing depth.

Link: http://archopht.jamanetwork.com/article.aspx?articleid=2422114

Miki A, Ikuno Y, Asai T, Usui S, Nishida K. Defects of the Lamina Cribrosa in High Myopia and Glaucoma. PLoS One. 2015;10(9):e0137909.

Purpose: We evaluated the prevalence and characteristics of the defects of the lamina cribrosa (LC) in high myopia and glaucoma, and compared them with control eyes using swept-source optical coherence tomography (SS-OCT).
Methods: One hundred fifty-nine eyes of 108 participants were divided into four subgroups; high myopia with glaucoma (MG, 67 eyes of 46 subjects), glaucoma without high myopia (G, 22 eyes of 13 subjects), high myopia without glaucoma (M, 35 eyes of 29 subjects), and a control group with neither glaucoma nor high myopia (C, 35 eyes of 20 subjects). The LC defects were identified and located using a standardized protocol in serial horizontal OCT scans. The prevalence rates of the defects were compared among the groups. Demographic and ocular factors were compared between eyes with and without defects.
Results: LC defects were observed in one eye (0.03%) in the C group, 8 eyes (22.9%) in the M group, 11 eyes (50%) in the G group, and 28 eyes (41.8%) in the MG group. The prevalence rates of the defects differed significantly among the groups (P = 0.0009). Most eyes with defects in the G and MG groups (79.5%) had damage in the corresponding visual hemifields. Other factors such as visual acuity, intraocular pressure, axial length, refractive error, disc ovality, or parapapillary atrophy area did not differ significantly between eyes with and without LC defects.
Conclusions: High myopia and glaucoma significantly increased the risk of LC damage. The LC damage in non-glaucomatous highly myopic eyes may at least partly explain the increased risk of developing glaucoma in myopic eyes.

Significance: Swept source OCT (DRI OCT-1 Atlantis in this study) is useful for analyzing structures located in deeper tissues such as the lamina cribosa.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4569299/

Swept Source Optical Coherence Tomography -

Comparison with Other Retinal Imaging Techniques

Jirarattanasopa P, Ooto S, Tsujikawa A, Yamashiro K, Hangai M, Hirata M, et al. Assessment of macular choroidal thickness by optical coherence tomography and angiographic changes in central serous chorioretinopathy. Ophthalmology. 2012 Aug;119(8):1666-78.

Objective: To investigate the relationship between macular choroidal thickness measured by high-penetrating swept-source optical coherence tomography (SS-OCT) and angiographic findings in central serous chorioretinopathy (CSC).
Design: Prospective cross-sectional case series.
Participants and Controls: Thirty-four patients with CSC (44 eyes) and 17 volunteer subjects (17 normal eyes).
Methods: All subjects underwent a comprehensive ophthalmologic and SS-OCT prototype examination. All patients with CSC also underwent simultaneous fluorescein angiography (FA) and indocyanine green angiography (IA). Mean regional horoidal thickness measurements on the Early Treatment Diabetic Retinopathy Study (ETDRS) layout and squared sector grids were obtained by 3-dimensional raster scanning using SS-OCT.
Main Outcome Measures: Macular choroidal thickness and angiographic abnormalities.
Results: Mean whole macular choroidal thickness in eyes with CSC (total, 329.3±83.0 μm; classic CSC, 326.9±83.1 μm; chronic CSC, 325.4±93.3 μm; and multifocal posterior pigment epitheliopathy, 359.0±15.5 μm) was greater than that in normal eyes (233.0±67.0 μm) ($P < 0.001$). In unilateral cases, mean whole macular choroidal thickness was greater in eyes with unilateral CSC than in unaffected fellow eyes ($P=0.021$). There was no significant difference in choroidal thickness between active eyes and resolved eyes in any of the ETDRS sectors. Mean choroidal thickness was greater in areas with leakage on FA than in areas without leakage ($P=0.001$). Mean choroidal thickness was greater in areas with choroidal vascular hyperpermeability and in areas with punctate hyperfluorescent spots on IA than in unaffected areas ($P<0.001$ for both).
Conclusions: Increased choroidal thickness was observed in the whole macular area of eyes with any of the CSC subtypes. Choroidal thickness was related to leakage from the retinal pigment epithelium, choroidal vascular hyperpermeability, and punctate hyperfluorescent lesions. These findings provide evidence that CSC may be caused by focally increased hydrostatic pressure in the choroid.

Significance The ability of Swept source OCT to provide a complete profile of choroidal thickness allows the detection and monitoring of pathologic conditions normally investigated by invasive techniques.

Link: http://www.sciencedirect.com/science/article/pii/S0161642012001650

Hayashi Y, Mitamura Y, Egawa M, Semba K, Nagasawa T. Swept-source optical coherence tomographic findings of choroidal osteoma. Case Reports in Ophthalmology. 2014 May;5(2):195-202.

Purpose: To report the morphologic features of a choroidal osteoma using swept-source optical coherence tomography (SS-OCT) and fundus autofluorescence (FAF).
Methods: Two eyes of two cases with a choroidal osteoma were studied using SS-OCT and FAF.
Results: The location of the tumor was circumpapillary without macular involvement in case 1 and juxtapapillary with macular involvement in case 2. Both cases had a mixture of calcified and decalcified areas, and a concomitant choroidal neovascularization was found in case 2. The FAF images showed decreased autofluorescence in the central decalcified regions and relatively preserved fluorescence in marginal calcified regions in both cases. SS-OCT revealed a normal inner retina and an abnormal outer retina in both cases, and subretinal fluid in case 2. The calcified regions appeared sponge-like and were multilayered in case 2. A lamellar reflective pattern was observed in the decalcified regions in case 1, and hyperreflective mound-like areas were observed in both cases. SS-OCT demonstrated hyperreflective areas above Bruch's membrane accompanied by disruption of Bruch's membrane in case 1. The chorioscleral border was visible in both cases.
Conclusions: The FAF pattern in the calcified and decalcified areas of the choroidal osteoma may correspond to the different stage of tumor evolution. The SS-OCT findings indicate that choroidal osteomas can have characteristic reflective patterns and alterations of the overlying retina.

Significance: Case series of eyes affected by choroidal osteoma. Swept source OCT is able to image the chorioscleral border in deep choroid region beneath the tumour, as well as providing visualization of structures within the tumour.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4127548/

Filloy A, Caminal JM, Arias L, Jordan S, Catala J. Swept source optical coherence tomography imaging of a series of choroidal tumours. Canadian Journal of Ophthalmology. 2015 Jun;50(3):242-8.

Objective: This pilot study aimed to describe the swept-source optical coherence tomography (SS-OCT) features of a series of choroidal tumours.
Design: This was an observational case series.
Participants: Patients in our ocular oncology unit were recruited: 32 eyes belonging to 31 patients.
Methods: All of the patients underwent fundus photography, ultrasonography (US), fundus autofluorescence (FAF), and SS-OCT. The main assessed characteristics were maximal tumour diameter and thickness, inner structure, and disturbances in the choroidal layers, sclera, retinal pigment epithelium, and retina.
Results: The tumours examined consisted of 16 nevi, 6 lesions with risk factors for growth, 4 melanomas, 4 hemangiomas, and 2 choroidal metastases. SS-OCT provided an accurate measurement of the tumour's maximum diameter in every case. Choroidal nevi displayed a compact, regular structure with a preserved choriocapillaris. Choroidal melanomas showed a more irregular inner structure, with an ablated choriocapillaris. Choroidal hemangiomas had a regular sponge like pattern. Choroidal metastases had an irregular inner structure organized in clumps and an ablated outer retina. In most of the pigmented tumours, the sclerochoroidal interface was not identifiable by SS-OCT. The presence of lipofuscin, detected by funduscopy and FAF, was also correlated with the SS-OCT findings.
Conclusions: SS-OCT provided a view of the inner structures of a series of choroidal tumours and assessed their associated structural anomalies, as well as obtained measurements of the diameter and thickness in most cases.

Significance: Swept source OCT provides high quality images, clearly displaying the structures from the vitreous to the sclera in one scan. The depth penetration and superior signal to noise ratio of swept source is useful when imaging choroidal tumours.

Link: http://www.sciencedirect.com/science/article/pii/S0008418215000861

Imai A, Toriyama Y, Iesato Y, Hirano T, Murata T. En face swept-source optical coherence tomography detecting thinning of inner retinal layers as an indicator of capillary nonperfusion. European Journal of Ophthalmology. 2015 Mar-Apr;25(2):153-8.

Purpose: To report en face swept-source optical coherence tomography (SS-OCT) as a noninvasive detection modality for regions of retinal layer thinning that are potential indicators of retinal nonperfusion areas (NPAs) in patients with branch retinal vein occlusion (BRVO).
Methods: Thirty-one eyes of 46 patients with BRVO showing a definite retinal NPA larger than 1 disc in diameter within the vascular arcades were included in this study. We calculated the overlapping correspondence ratio between presumed NPA, which appeared as a dark area in en face SS-OCT, and definite NPA in corresponding fluorescein angiography (FA) images. The correlation between brightness in en face SS-OCT images and corresponding ganglion cell complex (GCC) thickness determined by SD-OCT GCC maps was evaluated as well.
Results: Measured NPA size in FA and presumed NPA size in en face SS-OCT showed strong correlation (r = 0.746, p< 0.001) and colocalization. Reliable agreement between the 2 methods was confirmed by size comparisons (p = 0.11), with an overlapping correspondence ratio of 0.73.
Conclusions: The results suggest that en face SS-OCT is a noninvasive and relatively reliable method for delineating retinal thinning as an indicator of NPAs in eyes with BRVO. Because SS-OCT can be performed without mydriasis, this procedure may be an option for evaluating NPAs on a screening basis and during follow-up to reduce the number of FA examinations that carry very rare, but potentially fatal, allergic side effects.

Significance: The en face imaging provided by DRI OCT-1 Atlantis is a useful non-invasive method to evaluate retinal nonperfusion areas. Although this technique remains useful, it has now been surpassed by SS OCT Angio in which en face images of the microvascular structures enable highly accurate differentiation of nonperfused areas.

Link: http://www.eur-j-ophthalmol.com/article/en-face-swept-source-optical-coherence-tomography-detecting-thinning-of-inner-retinal-layers-as-an-indicator-of-capillary-nonperfusion

Pastor-Idoate S, Gil-Martinez M, Crim N, Quijano C, Biswas S, Charles S, et al. Swept-source optical coherence tomography of retinal cavernous hemangioma: a new imaging modality. Journal of Pediatric Ophthalmology and Strabismus. 2015;52 Online:e4-7.

Summary

The authors report a new, non-invasive diagnostic method in the diagnosis of retinal cavernous hemangioma (RCH). A 6-year-old girl was referred for a non-clearing retinal hemorrhage of 6 months' duration. Fourier-domain optical coherence tomography (FD-OCT) showed an intraretinal lesion with cystic-like internal appearance. Optical shadowing was present, preventing establishment of any subretinal component to the lesion. Swept-sourceOCT (SS-OCT) showed an intraretinal lesion consisting of a group of clearly defined grape-like caverns with overlying preretinal tissue. Wide-field fundus fluorescein angiography (WF-FFA) confirmed the diagnosis of RCH. SS-OCT was superior to FD-OCT in showing the internal anatomy of the RCH and allowing for the measurement of its structures, confirming the intraretinal location of the lesion and the presence of an associated preretinal tissue. SS-OCT may assist in cases in which hemorrhage prevents an accurate diagnosis by ophthalmoscopy or angiography, thus becoming an alternative imaging method to confirm the diagnosis of RCH while avoiding the risks of fluorescein angiography in children.

Significance: This paper illustrates the advantage of swept source over SD-OCT, particularly when pathology lies beneath haemorrhage and/or vascular structures. The long wavelength light source enables penetration of blood.

Link: http://www.healio.com/ophthalmology/journals/jpos/%7B6a4a08eb-6c73-4544-bf65-7ee6e8519fcf%7D/swept-source-optical-coherence-tomography-of-retinal-cavernous-hemangioma-a-new-imaging-modality

Sayanagi K, Gomi F, Akiba M, Sawa M, Hara C, Nishida K. En-face high-penetration optical coherence tomography imaging in polypoidal choroidal vasculopathy. British Journal of Ophthalmology. 2015 Jan;99(1):29-35.

Purpose: To assess the morphology of areas of complete retinal nonperfusion in eyes with branch retinal vein occlusion (BRVO) by en face images of optical coherence tomography (OCT).
Methods: Forty-six eyes with BRVO that underwent swept-source OCT (SS-OCT) and fluorescein angiography were enrolled. Depth-integrated images of the neural retina delineated by automated segmentation algorithm were obtained using SS-OCT. The findings in a 6 × 6-mm area on en face SS-OCT scans at the area of retinal nonperfusion were evaluated.
Results: Retinal nonperfusion was detected in 25 eyes. Of these, 20 (80%) eyes had multiple concaves of low reflectivity within an area of reticular high reflectivity (honeycomb sign) on depth-integrated images at the area corresponding to retinal nonperfusion. The mean area of retinal nonperfusionand honeycomb sign were 6.72 ± 4.10 mm2 and 4.19 ± 3.37 mm2, respectively. The area of retinal nonperfusion was correlated significantly ($r = 0.53$, $P < 0.001$) with the area of the honeycomb sign. The mean retinal thickness in eyes with a honeycomb sign increased significantly ($P = 0.017$) compared with eyes without a honeycomb sign. Furthermore, after anti-VEGF injection, the mean area of honeycomb sign decreased significantly ($P = 0.0013$), from 4.23 mm(2) to 0.48 mm(2).
Conclusions: Depth-integrated OCT images with automated layer segmentation showed a two-dimensional honeycomb-like structure in retinal nonperfusion with retinal edema. In eyes with BRVO, the thickness of retina did not decrease but increased due to retinal cysts in spite of neural retinal thinning.

Significance: This study demonstrates the similarity of findings of En face swept source OCT and fluorescein angiography in detecting vascular abnormalities. This represents a major advantage since it allows non-invasive evaluation of the condition. This technology has since been developed further with the release of SS OCT Angio – imaging of the fine microvascular structures without the need for dye.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2212809

Yu S, Bellone D, Lee SE, Yannuzzi LA. Multimodal imaging in foveal red spot syndrome. Retinal Cases & Brief Reports. 2015 Spring;9(2):97-101.

Purpose: To describe multimodal imaging findings in a patient with foveal red spot syndrome.
Methods: We report a case of a 57-year-old man with foveal red spot syndrome. Multimodal imaging techniques, including fundus color and red-free photographs, fluorescence angiography (Topcon 50DX; Topcon, Tokyo, Japan), MultiColor scanning laser imaging, spectral domain optical coherence tomography (Spectralis; Heidelberg Engineering, Heidelberg, Germany), swept source optical coherence tomography (DRI OCT-1 Atlantis; Topcon, Tokyo, Japan), adaptive optics (RTX-1; Imagine Eyes, Orsay, France), and microperimetry (MP1 Microperimeter; Nidek Technologies, Padua, Italy), were performed to confirm the diagnosis and determine the anatomical abnormalities related to the disease.
Results: Conventional clinical examination and imaging studies failed to explain the patient's visual dysfunction and this specific macular abnormality. Using advanced ophthalmic technologies, including MultiColor imaging, spectral domain optical coherence tomography with high-density acquisition, swept source optical coherence tomography, adaptive optics, and microperimetry, we identified the nature of the macular manifestation accounting for pathology of the foveal red spot syndrome and his visual dysfunction.
Conclusion: When conventional clinical examination and imaging techniques fail to identify the presence of and visual symptoms in foveal red spot syndrome, advanced technologies may be used to confirm the diagnosis and explain the etiology of the abnormality.

Significance: This case report shows how the improved visualization of cortical vitreous attained by DRI OCT-1 Atlantis allowed the imaging of subtle but important vitreomacular traction.

Link:http://journals.lww.com/retinalcases/Fulltext/2015/00920/MULTIMODAL_IMAGING_IN_FOVEAL_RED_SPOT_SYNDROME.1.aspx

Swept Source Optical Coherence Tomography -

Comparison to Other OCT Systems

Matsuo Y, Sakamoto T, Yamashita T, Tomita M, Shirasawa M, Terasaki H. Comparisons of choroidal thickness of normal eyes obtained by two different spectral-domain OCT instruments and one swept-source OCT instrument. Investigative Ophthalmology and Vision Science. 2013 Nov;54(12):7630-6.

Purpose: We compared the subfoveal choroidal thickness (SFCT) measured on the images obtained by two spectral-domain optical coherence tomographic (SD-OCT) instruments and one swept-source OCT (SS-OCT) instrument.
Methods: A cross-sectional, prospective noninterventional study was done in which SFCT was measured in the images obtained by two SD-OCTinstruments; Heidelberg Spectralis-OCT (Spectralis-SD-OCT) and Topcon 3D OCT-1000 Mark II (Topcon-SD-OCT). Images also were obtained with SS-OCT Atlantis DRI OCT-1 (DRI-SS-OCT). After manual segmentation, the measurements were made using the calipers embedded in each instrument. The intrarater, interrater, and intermachine agreements were assessed.
Results: We studied 35 subjects. The intrarater correlation coefficient (95% confidence interval) was 0.994 (0.988-0.994) for Spectralis-SD-OCT, 0.996 (0.993-0.998) for Topcon-SD-OCT, and 0.997 (0.991-0.998) for DRI-SS-OCT ($P < 0.001$). The interrater correlation coefficient was 0.995 (0.991-0.998) for Spectralis-SD-OCT, 0.995 (0.990-0.998) for Topcon-SD-OCT, and 0.996 (0.992-0.998) for DRI-SS-OCT ($P < 0.001$). The average SFCT was 273.2 µm with Spectralis-SD-OCT, 269.1 µm with the Topcon-SD-OCT, and 280.5 µm with DRI-SS-OCT. The intermachine correlation coefficient was 0.982 (0.964-0.991) for Spectralis-SD-OCT versus Topcon-SD-OCT, 0.907 (0.815-0.953) for Topcon-SD-OCT versus DRI-SS-OCT, and 0.911 (0.832-0.954) for DRI-SS-OCT versus Spectralis-SD-OCT ($P < 0.001$). The SFCT measured with DRI-SS-OCT was significantly thicker than that with Topcon-SD-OCT, with a mean difference of 11.41 ± 30.27 µm ($P = 0.032$).
Conclusions: In normal adult eyes, there was good reproducibility and repeatability of SFCT measurements obtained by the SD-OCT and SS-OCT instruments. However, the choroid measured with DRI-SS-OCT was thicker than that measured with both SD-OCT instruments, and, thus, the choroidal thickness should not be compared between the SD-OCT and SS-OCT instruments

Significance: Choroidal thickness measurements with DRI OCT-1 Atlantis has good reproducibility and repeatability compared to SD-OCT. Although highly correlated with SD-OCT the DRI OCT-1 Atlantis measures indicated a thicker choroid.

Link: http://iovs.arvojournals.org/article.aspx?articleid=2127890

Spaide RF, Akiba M, Ohno-Matsui K. Evaluation of peripapillary intrachoroidal cavitation with swept source and enhanced depth imaging optical coherence tomography. Retina. 2012 Jun;32(6):1037-44.

Purpose: To investigate the anatomic characteristics of peripapillary intrachoroidal cavitation using optical coherence tomography methodologies that are capable of deeper tissue penetration and consider pathophysiologic mechanisms of disease on the basis of the derived imaging information.
Methods: Consecutive eyes with peripapillary intrachoroidal cavitation were imaged with swept source optical coherence tomography with a 1-mm light source and in one eye with enhanced depth imaging spectral domain optical coherence tomography and 3-dimensional rendering. The anatomic layers were identified, and the induced abnormalities were evaluated.
Results: There were 16 eyes of 13 patients who had a mean age of 50.3 years and a mean spherical refraction of -12.5 diopters in the affected eyes. The lesion appeared as a yellowish-orange lobular region, usually inferior to the optic nerve, which was invariably tilted. The sclera was bowed posteriorly under the region of the intrachoroidal cavitation, while the overlying retina-retinal pigment epithelium-Bruch membrane complex showed little, if any deformation. Full-thickness defects in the retina at the inferior border of the conus were seen in four eyes and were associated with prominent cavitation within the choroid with marked posterior bowing of the sclera, but negligible deformation of the overlying retina inferior to the nerve.
Conclusion: Newer imaging modalities provided information about deeper structures in the eye not available in older studies that were performed with time-domain optical coherence tomography. This study demonstrated posterior deformation of the sclera in regions previously thinned by the ocular expansion that occurs in high myopia and imaged the resultant effects on the involved choroid.

Significance: Swept source OCT enables greater resolution and deeper penetration in ocular structures than older OCT modalities.

Link:
http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2012&issue=06000&article=00001&type=abstract

Miki A, Ikuno Y, Jo Y, Nishida K. Comparison of enhanced depth imaging and high-penetration optical coherence tomography for imaging deep optic nerve head and parapapillary structures. Clinical Ophthalmology. 2013;7:1995-2001.

Purpose: To evaluate and compare the abilities of enhanced depth imaging (EDI) and high-penetration optical coherence tomography (HP-OCT) to visualize the deep optic nerve head (ONH) and deep parapapillary structures.
Methods: Horizontal and vertical optic nerve images were obtained using EDI-OCT and HP-OCT, during the same visit, from 24 eyes of 12 patients with glaucoma. Three graders, using a three-point grading system, independently graded the visibility of the deep ONH structures (prelaminar tissue surface, anterior laminar surface, posterior laminar border, and laminar pores) and deep parapapillary structures (intrascleral vessels, cerebrospinal fluid space, and parapapillary choroid). The differences in the visibility scores between the EDI-OCT and the HP-OCT images and among the image locations were analyzed statistically. The agreement in scoring among the graders also was analyzed.
Results: The visibility of three ONH structures, the anterior laminar surface, posterior laminar border, and laminar pores, was significantly better with EDI-OCT ($P = 0.0010$, $P < 0.0001$, and $P = 0.0141$, respectively). In contrast, the visibility of all parapapillary structures was significantly better with HP-OCT ($P < 0.0001$, $P = 0.0176$, and $P < 0.0001$, respectively). The visibility scores were better in the vertical images compared with the horizontal images and were best in the temporal quadrants. The intergrader agreement was moderate for all parameters examined.
Conclusion: Both EDI-OCT and HP-OCT are useful for evaluating the deep ONH and parapapillary structures. The visibility scores of the deep ONH structures were better with EDI-OCT, in contrast to the better visibility scores of the deep parapapillary structures with HP-OCT. Both systems should be chosen depending on the target tissue to observe.

Significance: Swept source OCT and SD-OCT with EDI are useful tools to image the ONH and adjacent structures. The deeper choroid and intrascleral vessels are more visible with the SS-OCT than with the SD-OCT with EDI.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3797242/

Sato T, Mrejen S, Spaide RF. Multimodal imaging of optic disc drusen. American Journal of Ophthalmology. 2013 Aug;156(2):275-82 e1.

Purpose: To evaluate optic disc drusen, extracellular protein deposits known to contain numerous aggregates of mitochondria, using multimodal modalities featuring optical coherence tomography (OCT) and autofluorescence imaging.
Design: Retrospective observational case series.
Methods: Eyes with optic nerve drusen were examined with enhanced depth imaging (EDI)-OCT, swept source OCT, and fundus autofluorescence using a fundus camera.
Results: Twenty-six eyes of 15 patients with optic disc drusen were evaluated. EDI-OCT and swept source OCT showed multiple optic disc drusen at different levels; most were located immediately anterior to the lamina cribrosa. The drusen were ovoid regions of lower reflectivity that were bordered by hyperreflective material, and in 12 eyes (46.2%) there were internal hyperreflective foci. The mean diameter of the optic disc drusen as measured in OCT images was 686.8 (standard deviation ± 395.2) µm. There was a significant negative correlation between the diameter of the optic disc drusen and the global retinal nerve fiber layer thickness (r = -0.61, P = .001). There was a significant negative correlation between proportion of the optic disc drusen area occupied by optic nerve drusen as detected by autofluorescence imaging and the global retinal nerve fiber layer thickness (r = -0.63, P = .001).
Conclusions: Deeper-penetration OCT imaging demonstrated the internal characteristics of optic disc drusen and their relationship with the lamina cribrosa in vivo. This study also showed that both the larger the drusen and the more area of the optic canal occupied by drusen, the greater the associated retinal nerve fiber layer abnormalities.

Significance: Swept source OCT-1 Atlantis and SD-OCT with enhanced depth imaging are able to precisely characterize the size, depth and location of optic disc drusen.

Link: http://www.sciencedirect.com/science/article/pii/S0002939413002274

Copete S, Flores-Moreno I, Montero JA, Duker JS, Ruiz-Moreno JM. Direct comparison of spectral-domain and swept-source OCT in the measurement of choroidal thickness in normal eyes. British Journal of Ophthalmology. 2014 Mar;98(3):334-8.

Objective: To compare spectral-domain optic coherence tomography (SD-OCT) and swept-source OCT (SS-OCT) in the study of choroidal thickness (CT) in healthy eyes.
Methods: Prospective, cross-sectional, single-centre study. 82 healthy eyes of 46 patients were included. In a single session, Topcon 3D-2000 SD-OCT and 1050 nm SS-OCT prototype devices were used to perform OCT scans using a single line protocol. Two masked investigators independently, manually determined 13 CT measurements consisting of one subfoveal (SFCT), and six measurements on either side of the fovea (nasal and temporal) taken every 500 microns apart. The mean CT (MCT) was the mean average of these 13 measurements.
Results: SD-OCT was able to reproducibly measure the CT in 74.4% of eyes vs 100% with SS-OCT ($p<0.05$; Fisher's Exact test). In those eyes measured by both systems, mean SFCT was 279.4 ± 96.9 µm (range, 84-506) with SD-OCT vs 285.7 ± 88.9 µm (range 130-527) with SS-OCT($p=0.11$; Student's t test paired data). Mean MCT was 243.8 ± 78.8 µm (range 103.6-433.2) with SD-OCT vs 242.2 ± 81.8 µm (range 97.6-459) with SS-OCT ($p=0.64$; Student's t test paired data). The difference in SFCT and MCT was not statistically significant between both devices. Intraclass correlation coefficient was higher than 0.9 for interobserver and interdevice measurements. SFCT Bland-Altman plots showed 95% interobserver measurement agreement within ±34 for SD-OCT, ±22 for SS-OCT and ±60 µm intersystems.
Conclusions: SS-OCT permitted accurate identification of the choroido-scleral border in 100% of normal eyes, suggesting that SS-OCT was the superior modality for the measurement of CT.

Significance: SS-OCT prototype (Topcon) and SD-OCT are highly correlated for choroid thickness measurement, but best image quality was obtained with SS-OCT, allowing higher measurement rates and accuracy in eyes with thicker choroids.

Link: http://bjo.bmj.com/content/98/3/334.long

Hamzah F, Shinojima A, Mori R, Yuzawa M. Choroidal thickness measurement by enhanced depth imaging and swept-source optical coherence tomography in central serous chorioretinopathy. BMC Ophthalmology. 2014;14:145.

Background: We evaluated subfoveal choroidal thickness measured with two different forms of optical coherence tomography (OCT): enhanced-depth imaging (EDI) and swept-source (SS) OCT, in central serous chorioretinopathy (CSC).
Methods: Fifty-six eyes of 48 patients diagnosed with acute or chronic CSC, were studied prospectively. Subfoveal choroidal thickness was measured as the distance between the outer border of the retinal pigment epithelium-Bruch's membrane complex, and the chorioscleral border under the fovea. Subfoveal choroidal thickness was measured using EDI-OCT and SS-OCT. We also measured serous retinal detachment (SRD) only with SS-OCT. The Pearson correlation coefficient was used to assess the correlation between subfoveal choroidal thickness values determined by the two different OCT modalities.
Results: The mean patient age was 52 ± 13 years (range, 32-82 years). Among the 56 eyes, 21 had acute CSC and 35 had chronic CSC. Subfoveal choroidal thickness measured with EDI-OCT was 336.6 ± 91.6 µm in acute and 388.0 ± 103.4 µm in chronic CSC. With SS-OCT, the thickness in acute CSC was 332.0 ± 96.7 µm and that in chronic CSC was 392.6 ± 101.3 µm. Acute CSC ($p < 0.001$, correlation coefficient; $r = 0.99$) and chronic CSC ($p < 0.001$, correlation coefficient; $r = 0.97$) values obtained with the two different OCT modalities correlated significantly. Among the 56 eyes, 43 (19 eyes with acute and 24 with chronic CSC) were evaluable for SRD height by SS-OCT. The mean SRD height was 128.9 ± 83.6 µm in acute cases and 96.3 ± 62.0 µm in chronic cases.
Conclusions: Subfoveal choroidal thickness obtained with two different OCT modalities correlated significantly.

Significance: The swept source DRI OCT-1 Atlantis and SD-OCT with EDI were similar in systematically measuring choroid thickness in eyes with central serous chorioretinopathy and showed significant correlation.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4255445/

Lee KM, Woo SJ, Hwang JM. Evaluation of congenital excavated optic disc anomalies with spectral-domain and swept-source optical coherence tomography. Graefe's Archives for Clinical and Experimental Ophthalmology. 2014 Nov;252(11):1853-60.

Purpose: To investigate the anatomic characteristics of congenital excavated optic disc anomalies by using fundus photography, spectral-domain optical coherence tomography (SD-OCT), and swept-source optical coherence tomography (SS-OCT).
Methods: Fourteen eyes from 13 patients with congenital excavated optic disc anomalies underwent a complete ophthalmologic examination that included best-corrected visual acuity evaluation, fundus photography, and SD-OCT. SS-OCT was performed in cases of peripapillary staphyloma in which the excavation depth could not be detected with SD-OCT. On the basis of the fundoscopic and OCT findings, patients were classified as morning glory syndrome, optic disc coloboma, or peripapillary staphyloma.
Results: Seven eyes with morning glory syndrome were characterized by the presence of the preretinal tractional membrane in front of the excavated optic disc and could be divided into two groups: three eyes without retinal excavation, and four eyes with retinal excavation. Four eyes with optic disc coloboma showed inferiorly decentered scleral excavations with shallow optic disc excavation detectable by SD-OCT. Three eyes with peripapillary staphyloma showed deep excavation, the depth of which could not be detected by SD-OCT. SS-OCT and enhanced depth imaging SD-OCT images focused on the bottom revealed membranous structure at the bottom of the excavation in two cases with peripapillary staphyloma.
Conclusions: SD-OCT and SS-OCT are helpful for differential diagnosis of excavated optic disc anomalies. Morning glory syndrome, optic disc coloboma, and peripapillary staphyloma were respectively characterized by the presence of a preretinal tractional membrane, inferiorly decentered excavation, and an excavation deeper than that observed in morning glory syndrome and optic disc coloboma.

Significance: Swept source OCT (DRI OCT-1 Atlantis) and SD-OCT are useful in investigating the optic nerve head anomalies but swept source is necessary to detect features at the deepest point in retinal excavation. This is because of the clarity of the image at different depths and the maintenance of a good signal to noise ratio with depth.

Link: http://link.springer.com/article/10.1007%2Fs00417-014-2680-9

Lim LS, Cheung G, Lee SY. Comparison of spectral domain and swept-source optical coherence tomography in pathological myopia. Eye (London). 2014 Apr;28(4):488-91.

Purpose: To compare optical coherence tomography (OCT) images obtained with swept-source OCT (SS-OCT) and spectral domain OCT (SD-OCT) in pathological myopia.

Methods: This is a comparative observational cases series. Five patients with pathological myopia underwent SD-OCT and SS-OCT imaging. SS-OCT was performed using a prototype system (Topcon Medical Systems). SD-OCT was performed using enhanced depth imaging on the Heidelberg Spectralis OCT. The closest corresponding scans from the central subfield were compared.

Results: Eight eyes of five patients with pathological myopia were included (mean spherical equivalent: -16.00 ± 4.70 D). Overall, SS-OCT better visualized retino-choroidal structures. The choroid, inner segment (IS)/outer segment (OS) line, and external limiting membrane (ELM) were clearly seen in a higher proportion of SS-OCT than SD-OCT scans, ($P<0.01$ for all) whereas visualization of the sclera and retinal pigment epithelium (RPE) were similar. SS-OCT demonstrated foveoschisis in four eyes, with one of these not visible on SD-OCT. The wider SS-OCT scan revealed additional pathology not visible using SD-OCT along the staphyloma walls in 4/8 images. These included incomplete posterior vitreous detachment in one eye and peripheral retinoschisis in 3/8 eyes. Vitreoschisis was visible in 3/8 SS-OCT images but not in the SD-OCT images.

Conclusion: SS-OCT is useful for imaging the posterior staphyloma of pathological myopia, providing greater detail than SD-OCT.

Significance: Swept source OCT (DRI OCT-1 Atlantis in this case) is better at imaging highly myopic eyes than conventional SD-OCT and greater penetration allows for visualization of additional pathology.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3983632/

Park HY, Shin HY, Park CK. Imaging the posterior segment of the eye using swept-source optical coherence tomography in myopic glaucoma eyes: comparison with enhanced-depth imaging. American Journal of Ophthalmology. 2014 Mar;157(3):550-7.

Purpose: To compare the detection rates of identifying the posterior border of the sclera and lamina cribrosa and measurement reproducibility of scleral and laminar thicknesses using the enhanced depth imaging (EDI) of Heidelberg Spectralis optical coherence tomography (OCT) and swept-source OCT.
Design: Cross-sectional design.
Methods: Both EDI-OCT and swept-source OCT images were obtained in 32 myopic glaucoma patients. Subfoveal choroidal, subfoveal scleral, and central laminar thicknesses were measured from obtained B-scan images. Each measurement was performed at 3 locations by 2 masked observers. The detection rates and measurement reproducibility were evaluated from selected B-scans.
Results: The posterior border of the sclera was visible in 10 eyes (31%) using EDI-OCT. This was improved to be visible in 17 eyes (53%) using swept-source OCT. According to the McNemar $\chi(2)$ test, the detection rate of the posterior border of the sclera was significantly different between EDI-OCT and swept-source OCT ($P = 0.008$). The detection rate of the posterior border of the lamina cribrosa was similar for the 2 devices. In highly myopic eyes, the detection rate of the posterior border of the sclera and lamina cribrosa was not statistically different between EDI-OCT and swept-source OCT. Intersystem ICCs was 0.769 (95% CI, 0.714-0.893) for subfoveal scleral thickness and 0.900 (95% CI, 0.887-0.917) for laminar thickness. The mean subfoveal scleral thickness was 464.32 ± 213.24 µm using EDI-OCT and 650.26 ± 222.30 µm using swept-source OCT. There was statistical difference in the measured subfoveal scleral thickness by the 2 devices ($P = 0.018$).
Conclusions: Compared with EDI-OCT, swept-source OCT had an advantage in imaging the posterior sclera. Imaging the lamina cribrosa was similar when using both devices.

Significance: Swept source OCT **(**DRI OCT-1 Atlantis in this paper) is better for visualization of the posterior sclera than SD-OCT with EDI. The border of the lamina cribosa is equally visualized by both systems.

Link: http://www.sciencedirect.com/science/article/pii/S0002939413007307

Francis JH, Pang CE, Abramson DH, Milman T, Folberg R, Mrejen S, et al. Swept-source optical coherence tomography features of choroidal nevi. American Journal of Ophthalmology. 2015 Jan;159(1):169-76 e1

Purpose: To investigate the morphologic characteristics of choroidal nevi using swept-source optical coherence tomography and compare this with enhanced-depth optical coherence tomography.
Design: Retrospective observational case series.
Methods: One choroidal nevus each from 30 eyes of 30 patients was included and received imaging with swept-source OCT (SS-OCT) and enhanced-depth imaging OCT (EDI-OCT). For SS-OCT, a scan acquisition protocol was used involving 12 mm horizontal and vertical scans in the posterior fundus. The main outcome measures were morphologic features of choroidal nevi obtained with SS-OCT imaging. These features were compared to images obtained with EDI-OCT. A 2-tailed Fisher exact test was the statistical method used.
Results: SS-OCT allowed for an appreciation of intralesional details: Of the 30 nevi imaged, intralesional vessels were apparent in 30 (100%), intralesional cavities in 6 (20%), intralesional granularity in 14 (47%), abnormal choriocapillaris in 25 (83%), and abnormal choriocapillaris confined to the tumor apex in 17 (58%). Distended bordering vessels were identified in 22 nevi (73%) and were significantly associated with the presence of previous or persistent subretinal fluid. Intrinsic hyperreflectivity with hyporeflective shadowing was significantly (P = .05) more apparent in 14 of 21 melanotic nevi (67%) compared with 2 of 9 amelanotic nevi (22%). Visualization of the complete nevus-scleral interface was significantly (P = .02) more apparent in 7 of 9 amelanotic nevi (78%) compared with 6 of 21 melanotic nevi (29%), and was not significantly related to tumor thickness (measured by ultrasound) or to tumor configuration. Tumor diameter (but not tumor height) was statistically significantly associated with secondary retinal changes (P = .05) and configuration (P = .01). EDI-OCT was equivalent at determining secondary retinal changes (P = .29), the presence of distended bordering vessels (P = 1), visualization of the nevus-scleral interface (P = .6), and hyporeflective gradation at the nevus-scleral interface (P = .33). However, in melanotic lesions, SS-OCT was significantly superior at visualizing intralesional vessels (P = .0002), intralesional granularity (P = .0005), and abnormal choriocapillaris (P = .0001).
Conclusion: Imaging of choroidal nevi with SS-OCT enables visualization of intralesional details such as vessels (present in 100% of tumors imaged), cavities, and granularity. For melanotic lesions, SS-OCT is significantly better at depicting certain intralesional characteristics compared to EDI-OCT. Distended bordering vessels were recognized in over two thirds of the nevi imaged and were significantly associated with previous or persistent subretinal fluid.

Significance: Swept source OCT (DRI OCT-1 Atlantis in this case) allowed significantly greater visualization of structures below melanin which were not visible with SD-OCT with EDI, making the SS-OCT a valuable diagnostic tool.

Link: http://www.sciencedirect.com/science/article/pii/S000293941400659X

Girard MJ, Tun TA, Husain R, Acharyya S, Haaland BA, Wei X, et al. Lamina cribrosa visibility using optical coherence tomography: comparison of devices and effects of image enhancement techniques. Investigative Ophthalmology and Vision Science. 2015 Feb;56(2):865-74.

Purpose: To compare the visibility of the lamina cribrosa (LC) in optic disc images acquired from 60 glaucoma and 60 control subjects using three optical coherence tomography (OCT) devices, with and without enhanced depth imaging (EDI) and adaptive compensation (AC).
Methods: A horizontal B-scan was acquired through the center of the disc using two spectral-domain (Spectralis and Cirrus; with and without EDI) and a swept-source (DRI) OCT. Adaptive compensation was applied post acquisition to improve image quality. To assess LC visibility, four masked observers graded the 1200 images in a randomized sequence. The anterior LC was graded from 0 to 4, the LC insertions from 0 to 2, and the posterior LC either 0 or 1. The effect of EDI, AC, glaucoma severity, and other clinical/demographic factors on LC visibility was assessed using generalized estimating equations.
Results: The anterior LC was the most detectable feature, followed by the LC insertions. Adaptive compensation improved anterior LC visibility independent of EDI. Cirrus+EDI+AC generated the greatest anterior LC visibility grades (2.79/4). For LC insertions visibility, DRI+AC was the best method (1.10/2). Visibility of the posterior LC was consistently poor. Neither glaucoma severity nor clinical/demographic factors consistently affected LC visibility.
Conclusions: Adaptive compensation is superior to EDI in improving LC visibility. Visibility of the posterior LC remains poor suggesting impracticality in using LC thickness as a glaucoma biomarker.

Significance: The DRI OCT-1 Atlantis with post processing of B-scan images provides the best visibility for visualizing lamina cribosa insertions and deeper, fainter structures. When imaging the anterior lamina cribrosa, swept source OCT performs similarly to SD-OCT when used with both enhanced depth imaging and image post processing (adaptive compensation).

Link: http://iovs.arvojournals.org/article.aspx?articleid=2212842

Ohtake-Matsumoto A, Keino H, Koto T, Okada AA. Spectral domain and swept source optical coherence tomography findings in acute retinal necrosis. Graefe's Archives for Clinical and Experimental Ophthalmology. 2015 May 27.

Summary: Acute retinal necrosis (ARN) is a devastating, potentially blinding ocular infection characterized by the clinical feature of progressive retinitis and the histopathological finding of severe retinal necrosis. Previously, reduced retinal thickness corresponding to necrotic lesions has been shown using time-domain optical coherence tomography (OCT). In this report, we analyzed serial OCT images of the macula and peripheral retina in an eye with ARN using the newer generation of OCT devices, including both spectral-domain (SD)-OCT and swept-source (SS)-OCT.

Significance: Swept-Source OCT (Topcon) is a valuable technique for imaging fine features within the retinal structure.

Link: http://link.springer.com/article/10.1007%2Fs00417-015-3051-x

Tan CS, Chan JC, Cheong KX, Ngo WK, Sadda SR. Comparison of retinal thicknesses measured using swept-source and spectral-domain optical coherence tomography devices. Ophthalmic Surgery, Lasers & Imaging Retina. 2015 Feb;46(2):172-9.

Background and Objective: To compare retinal thicknesses measured using swept-source optical coherence tomography (SS-OCT) and spectral-domain (SD) OCT devices.
Patients and Methods: In a cohort study of 76 healthy eyes and 21 eyes with high myopia, mean retinal thicknesses in ETDRS subfields were compared between OCT scans obtained from the Topcon DRI OCT-1 (Topcon, Tokyo, Japan), Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany), and Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA).
Results: Central retinal thickness measurements differed significantly among the three OCT devices (Spectralis: 271 µm; Cirrus: 254 µm; DRI OCT-1: 238 µm; $P < .001$), with mean differences ranging from 15.6 µm to 37 µm. Intraclass correlation coefficients were at least 0.94 for any pair of machines. Similar results were observed in all nine ETDRS subfields. In all sectors, retinal thickness measurements obtained using the 3-D and radial scans of the SS-OCT were similar (mean differences: 0.7 to 3.8 µm).
Conclusion: Retinal thickness measurements obtained from DRI OCT-1 and SD-OCT are different and should be accounted for when comparing results of OCT scans from different devices.

Significance: The retinal thicknesses measurements differ between different OCT devices, whether SD-OCT or SS-OCT. Patients should ideally be followed up on the same model of OCT.

Link: http://www.healio.com/ophthalmology/journals/osli/2015-2-46-2/%7B3c2bc91a-a752-4a60-8a90-b144f8d0e61c%7D/comparison-of-retinal-thicknesses-measured-using-swept-source-and-spectral-domain-optical-coherence-tomography-devices

Tan CS, Ngo WK, Cheong KX. Comparison of choroidal thicknesses using swept source and spectral domain optical coherence tomography in diseased and normal eyes. British Journal of Ophthalmology. 2015 Mar;99(3):354-8.

Background/Aims: Choroidal thickness measurements are reported to differ between swept source optical coherence tomography (SS-OCT) and spectral domain OCT (SD-OCT). This study aimed to assess the comparability of choroidal thickness measurements using SS-OCT and SD-OCT devices among patients with retinal diseases and normal participants.
Methods: In a prospective cohort study of 100 subjects, comprising patients with retinal disease and normal volunteers, OCT scans were performed sequentially with the DRI OCT-1 and Spectralis OCT using standardised imaging protocols. Subfoveal choroidal thicknesses were independently measured by masked reading-centre certified graders. Paired t tests and intraclass correlation coefficients (ICCs) were used to compare the measurements.
Results: Among all 100 participants, mean subfoveal choroidal thickness was 264.3 µm and 272.4 µm for DRI OCT-1 and Spectralis OCT respectively (p=0.001), with ICC of 0.989. The mean difference in choroidal thickness between OCT devices was larger among eyes with retinal diseases compared with normal eyes (8.4 µm vs 7.3 µm). Eyes with choroidal thickness ≤200 µm had smaller differences between OCT devices compared with those with thicker choroids (mean 3.6 µm vs 10.0 µm, p=0.021).
Conclusions: Subfoveal choroidal thickness measurements are comparable between DRI OCT-1 and Spectralis OCT. The presence of retinal disease increases the variability of choroidal thickness measurements between OCT devices.

Significance: Measurement of subfoveal choroid thickness are similar between DRI OCT-1 Atlantis and SD-OCT devices. Both systems are reliable in normal eyes but the visualization of choroid-scleral boundary had better quality with the SS-OCT and therefore thickness measurements in diseased eyes are likely to be more accurate.

Link: http://bjo.bmj.com/content/99/3/354.long

Ting DS, Cheung GC, Lim LS, Yeo IY. Comparison of swept source optical coherence tomography (SS-OCT) and spectral domain optical coherence tomography (SD-OCT) in polypoidal choroidal vasculopathy. Clinical and Experimental Ophthalmology. 2015 Jul 17.

Background: Swept source optical coherence tomography (SS-OCT, Topcon Medical System, Japan) is known to have longer wavelength than spectral domain OCT (SD-OCT, Spectralis, Heidelberg Engineering, Germany), allowing a deeper penetration into retina and choroidal layers. This objective of this study was to compare the visibility of retinal and choroidal features in polypoidal choroidal vasculopathy (PCV) using SS-OCT and SD-OCT.
Design: Prospective comparative observational case series in Singapore National Eye Center (SNEC) PARTICIPANTS: There were 20 eyes (20 patients) with PCV confirmed with indocyanine green angiogram (ICGA).
Methods: Six pre-specified OCT parameters (presence of polyps, sharp pigment epithelial detachment (PED) peak, notched PED and visibility of full maximum height of PED, inner segment/outer segment (IS/OS) line and choroid-scleral interface [CSI]) were graded using SS-OCT and SD-OCT.
Main Outcome Measures: The Kappa statistics between the two imaging modalities were calculated.
Results: Both SS-OCT and SD-OCT were able to detect polypoidal lesions in the majority of eyes (90% and 85% respectively). However, SS-OCT had better detection for CSI and IS/OS lines (CSI: 80% vs 45%, p=0.05; IS/OS line: 65% vs 45%, p=0.34). For sharp PED peak, notched PED, ability to visualize the full PED height, and RPE line, both OCT machines were able to detect in ≥80% of the eyes.
Conclusion: In conclusion, SS-OCT and SD-OCT appeared to be similarly effective at detecting most features associated with PCV. However SS-OCT is more superior in detecting the CSI.

Significance: Although SS-OCT and SD-OCT were found to be similar for the detection of most features of PCV, swept source was able to detect the CSI and identified the IS/OS line in more cases, and revealed more polyps than SD-OCT. This is likely to relate to the maintenance of good signal to noise ratio with depth.

Link: http://onlinelibrary.wiley.com/doi/10.1111/ceo.12580/abstract

Waldstein SM, Faatz H, Szimacsek M, Glodan AM, Podkowinski D, Montuoro A, et al. Comparison of penetration depth in choroidal imaging using swept source vs spectral domain optical coherence tomography. Eye (London). 2015 Mar;29(3):409-15.

Purpose: To compare signal penetration depth and deep structure-visualization of swept source (SS) and spectral domain (SD)-optical coherence tomography (OCT) with and without enhanced depth imaging (EDI) and B-scan averaging modes.
Methods: Volume scans were obtained from 20 eyes of healthy volunteers by DRI OCT-1, Spectralis using EDI and B-scan averaging, and Cirrus HD-OCT. The signal penetration depth was measured as the distance between the retinal pigment epithelium and the deepest visible anatomical structure at the foveal center. Visibility and contrast of the choroidoscleral junction and of vascular details within the choroid were assessed across the entire volume using an ordinal scoring scale. Outcome measures were compared using paired t-test and rank-sum test.
Results: The mean signal penetration depth was 498±114 µm for Spectralis, 491±85 µm for DRI OCT-1, and 123±65 µm for Cirrus; P=0.9708 Spectralis vs DRI OCT-1, P<0.0001 Spectralis vs Cirrus, and P<0.0001 DRI OCT-1 vs Cirrus. Mean ranks for visibility and contrast of the choroidoscleral junction were 3.83 for Spectralis, 3.98 for DRI OCT-1, and 2.00 for Cirrus; and 3.45 for Spectralis, 2.93 for DRI OCT-1, and 1.58 for Cirrus. Mean ranks for visibility and contrast of vascular details were 3.73 (Spectralis), 3.70 (DRI OCT-1), and 2.23 (Cirrus); and 3.53 (Spectralis), 2.05 (DRI OCT-1), and 1.98 (Cirrus).
Conclusion: Signal penetration depths are similar for SS-OCT and SD-OCT using EDI and frame averaging, and statistically significantly lower without EDI/averaging. Both SD-OCT using EDI/frame averaging and SS-OCT offer excellent visualization capabilities for volumetric imaging of the choroidoscleral interface.

Significance: Swept source (DRI OCT-1 Atlantis) was found to have similar signal penetration depths compared to SD-OCT with enhanced depth imaging, however there was not direct comparison of like for like scans (frame averaging for SD-OCT but only single frame scanning was available for SS-OCT at the time). The chorioscleral interface was visible in more eyes using SS-OCT than SD-OCT with EDI. Acquisition times were approximately 100x slower for SD-OCT with EDI compared to SS-OCT. Given the similar penetration depths the improved scanning speed, larger signal range and better penetration thorough media opacities of SS-OCT may result in a superior clinical applicability.

Link: http://www.nature.com/eye/journal/v29/n3/full/eye2014319a.html

Swept Source Optical Coherence Tomography –

Reviews and Future Directions

Mrejen S, Spaide RF. Optical coherence tomography: imaging of the choroid and beyond. Survey of Ophthalmology. 2013 Sep-Oct;58(5):387-429.

Summary: Seventy percent of the blood flow to the eye goes to the choroid, a structure that is vitally important to the function of the retina. The in vivo structure of the choroid in health and disease is incompletely visualized with traditional imaging modalities, including indocyanine green angiography, ultrasonography, and spectral domain optical coherence tomography (OCT). Use of new OCT modalities, including enhanced depth imaging OCT, image averaging, and swept-source OCT, have led to increased visualization of the choroidal anatomy. The correlation of these new anatomical findings with other imaging modalities results increases understanding of many eye diseases and recognises of new ones. The status of the choroid appears to be a crucial determinant in the pathogenesis of diseases such as age-related choroidal atrophy, myopic chorioretinal atrophy, central serous chorioretinopathy, chorioretinal inflammatory diseases, and tumors. Extension of these imaging techniques has provided insights into abnormalities of the sclera and optic nerve. Future developments will include blood flow information, 3D rendering of various ocular structures, and the ability to evaluate changes in 3D structural information over time (4D imaging).

Link: http://www.surveyophthalmol.com/article/S0039-6257(12)00300-1/abstract

Mansouri K, Nuyen B, R NW. Improved visualization of deep ocular structures in glaucoma using high penetration optical coherence tomography. Expert Review of Medical Devices. 2013 Sep;10(5):621-8.

Summary: The introduction of optical coherence tomography (OCT) has revolutionized ophthalmology through the ability to non-invasively image the retina in vivo. Glaucoma is the leading cause of irreversible blindness worldwide. Despite major advances in imaging techniques, the pathogenesis of glaucoma remains poorly understood at present. The lamina cribrosa (LC) is the presumed site of axonal injury in glaucoma. Its thinning and deformation have been suggested to contribute to glaucoma development and progression by impeding axoplasmic flow within the optic nerve fibers, leading to apoptosis of retinal ganglion cells. To visualize the deep ocular structures such as the choroid and the LC, OCT imaging has been used, particularly the enhanced depth imaging (EDI)-OCT modality of spectral domain (SD)-OCT. However, the posterior laminar surface especially is not seen clearly using this method. A new generation of OCTs, swept-source (SS)-OCT, is able to image the LC and the choroid in vivo. SS-OCT employs a longer wavelength compared with the conventional OCT, generally set at 1050 nm (instead of 840 nm). We review current knowledge of the LC, findings from trials that use SD-OCT and EDI-OCT, and our experience with a prototype SS-OCT to quantify choroid changes and visualize the LC in its entirety.

Link: http://informahealthcare.com/doi/abs/10.1586/17434440.2013.827505

Silverman AL, Tatham AJ, Medeiros FA, Weinreb RN. Assessment of optic nerve head drusen using enhanced depth imaging and swept source optical coherence tomography. Journal of Neuro-ophthalmology. 2014 Jun;34(2):198-205.

Background: Optic nerve head drusen (ONHD) are calcific deposits buried or at the surface of the optic disc. Although ONHD may be associated with progressive visual field defects, the mechanism of drusen-related field loss is poorly understood. Methods for detecting and imaging disc drusen include B-scan ultrasonography, fundus autofluorescence, and optical coherence tomography (OCT). These modalities are useful for drusen detection but are limited by low resolution or poor penetration of deep structures. This review was designed to assess the potential role of new OCT technologies in imaging ONHD.
Evidence Acquisition: Critical appraisal of published literature and comparison of new imaging devices to established technology.
Results: The new imaging modalities of enhanced depth imaging optical coherence tomography (EDI-OCT) and swept source optical coherence tomography (SS-OCT) are able to provide unprecedented in vivo detail of ONHD. Using these devices it is now possible to quantify optic disc drusen dimensions and assess integrity of neighbouring retinal structures, including the retinal nerve fiber layer.
Conclusions: EDI-OCT and SS-OCT have the potential to allow better detection of longitudinal changes in drusen and neural retina and improve our understanding of drusen-related visual field loss.

Link: http://journals.lww.com/jneuro-ophthalmology/pages/articleviewer.aspx?year=2014&issue=06000&article=00019&type=abstract

Chhablani J, Wu L. Update on choroidal vascular imaging using optical coherence tomography. Expert Review of Ophthalmology. 2014 2014/08/01;9(4):297-304.

Summary: The choroid being the most vascular tissue plays an important role in nutrition of outer retinal structures as well as the visual function. Recent literature provides information about the choroidal thickness and its change in various chorioretinal diseases. Detailed assessment of choroidal vasculature is yet to be explored. This review evaluates the undergoing research in choroidal vascular imaging using various optical coherence tomography techniques such as en-face, phase variance, and swept-source. The authors also discuss automated segmentation of choroidal vessels and its application in choroidal assessment as well as future directions.

Link: http://www.tandfonline.com/doi/abs/10.1586/17469899.2014.936386?journalCode=ierl20

Additional Articles (Free Viewing)

OCT Angiography in Age-Related Macular Degeneration
Retina Today, May/June 2015
Laura Kuehlewein, David Sarraf and Srinivas R. Sadda
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Link: http://www.topcon-medical.eu/files/EU_Downloads/Products/DRI-OCT-1/European_Ophthalmology_News_-Prof_P_Stanga-_Topcon_DRI_OCT-1.pdf

New OCT Technologies Take Imaging Deeper and Wider
Retinal Physician, Volume: 10 , Issue: March 2013, page(s): 42 - 48
Zofia Michalewska, Janusz Michalewski, Jerzy Nawrocki
Link: http://www.retinalphysician.com/articleviewer.aspx?articleID=108037

Swept-Source OCT: Wide-field simultaneous choroid, retina, and vitreous visualization
Retina Today, September 2013
Zofia Michalewska, Janusz Michalewski and Jerzy Nawrocki
Link: http://retinatoday.com/2013/09/swept-source-oct/

What's Next in Laser and OCT. Swept-source OCT and Non-damaging Laser Treatment
Review of Ophthalmology, March 2013
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