Basic concepts and terms of optical coherence tomography

**Acquisition protocol.** Protocol of data acquisition, scanning scheme. Specifies the scans parameters: their number and size, the number of A-scans in a B-scan (see A-scan and B-scan), the number of repeated measurements for averaging (see Averaging) etc. Most protocols specify also the location of the scan area and its dimensions.

**Analysis protocol.** The program (software) for processing of acquired data (determined by scanning scheme – see Acquisition protocol), and reporting the results of the study.

**A-scan.** The result of scanning at a single point [of the eye fundus]. It is an element (unit) of the scanning process. The set of A-scans forms B-scan (see B-scan). A-scan is a vertical line on the B-scan. Each A-scan, in turn, consists of points. The higher the number of points in A-scan, the higher is the resolution of the method.

**Averaging.** The technique of the processing of the repeated signals (OCT scans), allowing to enhance the stable (repeated) parts of the image and discard the noise, thereby improving the signal to noise ratio.

**B-scan (OCT scan, OCT image, scan, OCT).** The two-dimensional image of the cross-section (slice) of the structures of the eye fundus. Consists of A-scans (see A-scan). B-scan quality is determined by the number of A-scans in it and the number of points in each A-scan.

**Fourier domain OCT.** See Spectral domain OCT.

**Imaging methods.** Diagnostic examinations based on acquisition of images, typically in digital format, which allows them to be subjected to a precise quantitative analysis.

**OCT grid.** A measurement grid, subdividing macular area into 9 zones. It consists of three concentric circles with a diameter of 1, 3 and 6 mm and radial lines separating the middle and outer circles into 4 equal parts. (Another name is ETDRS-grid, but it is less correct, because originally the size of the ETDRS-grid was dependent on the size of the optic disc).

**Reflectivity.** The property of tissue or other object to reflect light. Reflectivity is connected to the optical density – ability of tissue or other object to transmit light. Usually the higher the reflectivity, the higher is the optical density.

**Resolution.** The ability of the device (here - the OCT device) to resolve and measure the minimum details in the object that is being imaged. Axial resolution determines the accuracy of the measurements of retinal layers thicknesses and the distances between them (alongside the optical axis of the eye). Transverse (lateral) resolution characterizes the accuracy of measurements in the plane perpendicular to the optical axis of the eye (at the level of certain layer of the retina; on the screen of OCT device it is usually in a horizontal direction).

**Segmentation.** Layer-by-layer analysis of the structures of the eye fundus. It allows to select a specific layer or group of layers and form a map of its (their) thickness.

**Spectral domain OCT or spectral OCT.** Modification of OCT based on the processing of the signal (light reflected from tissues) with the help of a special mathematical method, called a spectral (or Fourier) analysis. It allows to increase the speed and resolution of OCT by several orders of magnitude. Also called Fourier domain OCT.
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Epiretinal Fibrosis, Macular Edema

Decreased vision in the right eye of this 63-year-old woman was found when she came to change glasses. She did not notice it due to a high visual acuity in the left eye. At presentation right visual acuity was 20/63.

A. Fundus photograph. In the central area of the fundus is observed a widespread fibrotic membrane extending to the main vessel arcades, sometimes quite dense, causing marked retinal wrinkling, partial screening of retinal vessels and macular edema.

B-E. SD-OCT. Full Retinal Thickness map (B) demonstrates pronounced (mostly in white color) thickening of the macula in the central and upper parts. Just as in the previous case, OCT grid significance map (C) by its pink color reflects “pathological” thickening of the retina. Pronounced diffuse macular edema is observed on the vertical scan through the center of the fovea, presented both in color (D) and black-and-white (E) formats. On the surface of the retina there is an epiretinal membrane, very thick in some places and with signs of separation from the retina (arrow). In the neighboring region (arrowhead) the splitting (schisis) of tissues is caused by exposure to strong traction. Apparently the epiretinal membrane itself is splitting, but we cannot exclude that the process involves the superficial layers of the retina as well.
Case 8

Lamellar Macular Hole

This 52-year-old woman with a history of lamellar macular hole in her right eye reported moderate distortion of the central vision in this eye for 1.5 years. At presentation her right visual acuity was 20/50 and it did not change in the last 1.5 years.

A. Fundus photograph (30°) shows evidence of a macular hole with distinct edges and mild epiretinal membrane at the superior and temporal edges of the hole.

B-D. SD-OCT. The vertical black-and-white OCT scan through the central fovea (B) shows abnormally deep and steepened foveal contour. Retinal tissue is present at the base of the hole defining it as a lamellar hole. The edges of the hole are thickened and edematous with intraretinal splitting (pseudocyst formation). It is unlikely that mild epiretinal membrane over the superior hole edge (arrows) is the reason for the lamellar hole formation. Posterior vitreous is only partially detached with vitreomacular adhesion still present and continuing to exert traction on the retina. The horizontal color OCT scan (C) demonstrates similar changes, though the lamellar hole does not look so deep. Another vertical color OCT scan through the nasal fovea (D) shows elevated inferior edge of the hole with separation of the inner retinal layers typical for lamellar macular holes. As always, only simultaneous studying of different scans could give full understanding of the nature of the changes. For example, the large pseudocyst on the scan B is in fact not a cyst, but the continuation of the separation of the inner retinal layers (splitting) seen on the adjacent scan D.
Case 12

Stage 2 Macular Hole

A 57-year-old woman noted a decrease in vision in her left eye for three weeks. She underwent macular hole surgery in the fellow eye 4 months ago. At presentation her left visual acuity was 20/50.

A. Left eye Thickness Map of the retina shows only significant thickening of the retina in the foveal area (red and white colors) without central thin (blue) spot typical of a full-thickness macular hole.

B-C. SD-OCT of the left eye. The horizontal color OCT scan through the hole center (B) shows a full-thickness macular hole almost completely covered by an operculum that prevents the visualization of the hole on the retinal Thickness Map (A). Posterior hyaloid face is poorly visible, but perifoveal vitreous detachment with persistent vitreous attachment at the operculum and at the optic disc can still be discerned. The vitreous attachment at the operculum is seen also on the vertical black-and-white OCT scan (C). On this scan the hole is completely covered by the base of the operculum. There is also a partially separated epiretinal membrane (arrow) with typical saw-toothed appearance of the retinal surface.
Hypertensive Retinopathy with Soft Exudate

This 57-year-old woman was referred to OCT due to a “yellow lesion” in the left retina discovered during a regular medical examination. She reported a history of essential hypertension (systolic blood pressure often higher than 160 mmHg). At presentation her left visual acuity was 20/20; she had not complained about any problems with this eye.

A. Fundus photograph. A cotton-wool spot (soft exudate) is observed along the superotemporal retinal artery. There are other changes apparently not connected with hypertension – yellowish spots between soft exudate and optic disc and parfoveally; slight deformation of the fovea.

B-F. SD-OCT. The retinal Thickness Map (B) shows an oval white area of retinal thickening, which corresponds to the soft exudate. The horizontal color (C) and the vertical black-and-white (D) OCT scans through the cotton-wool spot demonstrate that it is located in the nerve fiber layer. Despite the shadow from the soft exudate it is possible to see the intact pigment epithelium, but other layers are not visible in the shadow. The horizontal OCT scan through the yellowish spots (E) shows two small elevations of the pigment epithelium resembling the drusen (arrows). Another horizontal OCT scan through the foveal center (F, taken without averaging) shows slight deformation of the foveal pit contour from the vitreous traction. Near the fovea the posterior hyaloids face is not visible, but its two-humped profile suggests a vitreous attachment to the fovea (see Cases 9, 13).
Proliferative Diabetic Retinopathy with Macular Edema after Scatter Laser Coagulation

This 52-year-old woman with a 7-year history of type 2 diabetes mellitus complained of gradual decrease in vision. She was treated with insulin injections for the last two years. A year ago scatter laser coagulation was performed in the left eye in a district hospital. At presentation her left visual acuity was 20/63.

A. Fundus photograph of the left eye shows moderate macular edema. There are multiple laser coagulation scars with hemorrhages among them mostly in the temporal retina, and microaneurysms. Mild fibrous proliferation with new vessels is observed on the optic disc.

B-D. SD-OCT of the left eye. The Full Retinal Thickness map (B) shows moderate thickening (edema) of the nasal macula (red color), while the fovea and temporal macula have normal thickness. There is an area of local thinning (blue color) in the superonasal retina (corresponds to the place of intense coagulation in the photograph). The horizontal OCT scan through the central fovea (C) shows cystoid macular edema (retinal thickening with middle-sized cysts in the inner nuclear layer) nasally to the foveola. There is an oval-shaped structure (neovascular fibrous proliferation) on the optic disc protruding into the vitreous. The vertical OCT scan (D) in the area of laser photocoagulation shows mild retinal thinning. Three laser coagulation scars with deformation of all retinal layers are observed in this scan. The pigment epithelium in the scars is disrupted and light rays penetrate deep into the choroid. Subtle epiretinal membrane is visible in the superior (left) part of the scan.

Decreased optical density (reflectivity) of the outer retinal layers, especially of the retinal pigment epithelium (for example, in the area of laser photocoagulation or old chorioretinal scar) allows light rays to penetrate deep into the choroid. In such places choroid looks optically more dense than usual. However it should not be regarded as a real increase in its optical or physical density.