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Review article

Retinal complications associated with congenital optic disc anomalies determined by swept source optical coherence tomography☆

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ABSTRACT

Optical coherence tomography has evolved over the past 2 decades to be an important ancillary method to evaluate diseases of the anterior and posterior segments of the eye. The more recent development of swept-source optical coherence tomography (SS-OCT) with a wavelength-tunable laser centered at 1050 nm and deeper imaging depth of 2.6 mm has enabled clinicians to evaluate congenital optic disc anomalies including optic disc pits, optic disc colobomas, and morning glory syndrome in more detail. The SS-OCT findings of the posterior precortical vitreous pocket, Cloquet's canal, lamina cribrosa that is torn from the peripapillary sclera, and the retrobulbar subarachnoid space immediately posterior to the highly reflective tissue lining the bottom of the excavation are presented. In addition, abnormal communications between the vitreous cavity and the subretinal and subarachnoid spaces in eyes with congenital optic disc anomalies are also reviewed. The retinal complications associated with congenital optic disc anomalies are treated by vitreous surgery, silicone oil tamponade, and peripapillary laser photocoagulation or scleral buckling. However, the surgical outcomes are limited and not entirely satisfactory. Analyses by SS-OCT of congenital optic disc anomalies should make the treatment correspond better with the pathological findings.

1. Introduction

Congenital optic disc anomalies consist of optic disc pits, optic disc colobomas, the morning glory syndrome, optic nerve aplasia or hypoplasia, and peripapillary staphylomas.[1–5] Congenital optic disc pits are anomalies of the optic nerve head and are commonly associated with retinoschisis and serous retinal detachment.[3–5] Other optic disc anomalies are associated with serous or rhegmatogenous retinal detachment. Optical coherence tomography (OCT) studies of eyes with optic disc pit maculopathy show the presence of double-layer detachments consisting of an inner layer retinoschisis and an outer layer detachment.[6] It has not yet been determined whether the fluid in the retinoschisis originates from the vitreous cavity or from leakage of cerebrospinal fluid through the peripapillary subarachnoid space.[4]

OCT has evolved over the past 2 decades to be an important ancillary method to evaluate the anterior and posterior segments of eyes with ocular diseases.[7,8] OCT is noninvasive and cross-sectional or enface images of the anterior segments, retina, choroid, and the optic nerve head can be obtained. The improved high-resolution images have enabled clinicians to obtain images that are comparable to the *in vivo* histological cross-sectional images.

Swept-source OCT (SS-OCT) is a new generation OCT that has higher penetration into the choroid and sclera.[9] SS-OCT uses a longer wavelength examination beam of around 1 μm, which allows it to examine the choroid and deeper tissues of the eye. SS-OCT can evaluate the retrobulbar subarachnoid space, vascular structures within the posterior sclera, peripapillary intrachoroidal cavitation, and orbital fat of eyes with high myopia.[10–14] The microstructures of the lamina cribrosa have been evaluated by SS-OCT in eyes with glaucomatous disc cupping in three-dimensional analyses.[15–17] We discuss the efficacy of SS-OCT in evaluating congenital optic disc anomalies.

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1.1. Advancement of OCT technology

The earlier OCT models used a near-infrared light source to create cross-sectional images of the retina.[7] The scanning light is divided into two pathways: a reference pathway and a sampling pathway. The sampling pathway passes through the tissue, and the light is scattered and reflected from different tissues in the retina. It is then combined with the light of the reference pathway that is reflected from a reference mirror. The interference pattern caused by the differences in coherence of the two beams is used to create axial A-scan images of the tissue at the point of the same distance to the reference mirror.[7] Thus, the reference mirror needs to move frequently to create two-dimensional tomographic images from the axial A-scan images, which is called time-domain detection.

The spectral-domain OCT (SD-OCT) system detects light echoes by simultaneously measuring the interference spectrum using an interferometer with a high-speed spectrometer instead of a moving reference mirror.[18,19] A much faster A-scan of the SD-OCT compared to time-domain OCT enables the acquisition of multiple B-scan images in a short time. Multiple B-scans from the identical retinal location are then averaged to increase the signal-to-noise ratio.[20] Image averaging makes the SD-OCT images clearer by reducing speckle noises and with a slight increase in the resolution. Enhanced depth imaging with SD-OCT can obtain images of the choroid and posterior sclera more precisely and accurately.[21,22] Enhanced depth imaging OCT images are obtained by positioning the SD-OCT device close enough to the eye to obtain an inverted image that has better contrast in deeper areas than the usual OCT images. The inverted images sharpen the continuity and enhance the retinal and choroidal features using image averaging.

SS-OCT uses another form of spectral domain detection to measure the light echoes.[9] SS-OCT employs a tunable frequency-swept laser light source, which sequentially emits various frequencies in time, and the interference spectrum is measured by photodetectors instead of a spectrometer. This technology increases the signal quality in deeper tissues by eliminating the sensitivity of the spectrometer to a higher frequency modulation, thereby improving the resolution of the choroid and posterior sclera. The SS-OCT (DRI OCT-1 Atlantis; Topcon, Tokyo, Japan) has an A-scan repetition rate of 100,000 Hz and the light source is a wavelength-tunable laser centered at 1050 nm with a 100-nm tuning range. The axial resolution is 8 μm, the lateral resolution is 20 μm, and the imaging depth is 2.6 mm.[23,24]

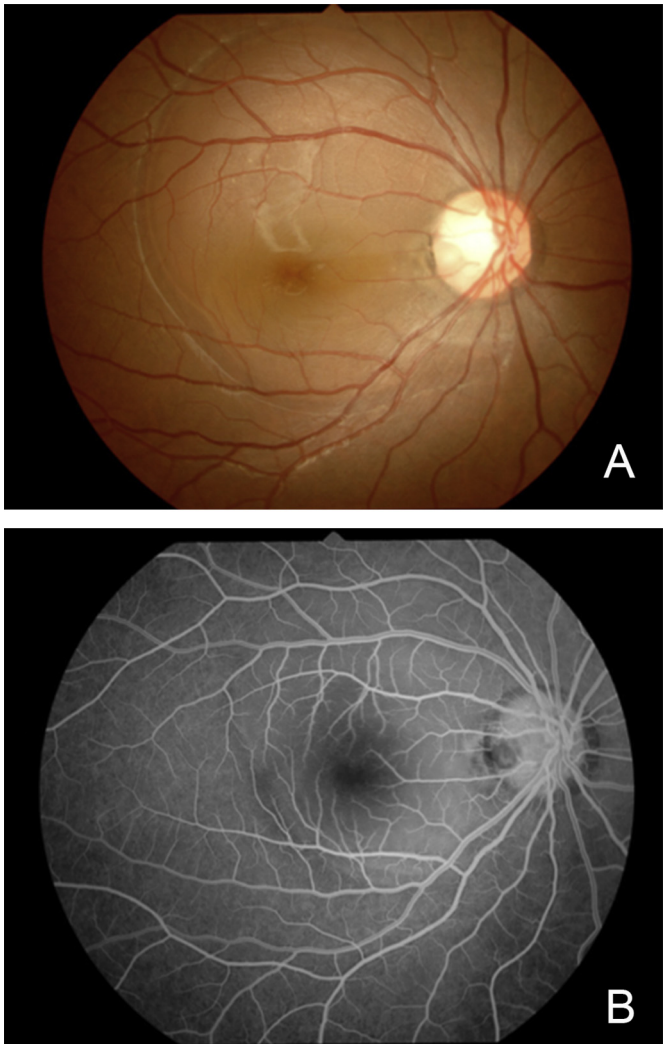

Fig. 1. Fundus photograph and fluorescein angiogram of a 17-year-old woman with optic pit maculopathy. (A) Fundus photograph showing serous retinal detachment connected to an optic pit at the temporal edge of the optic disc; (B) fluorescein angiogram in early phase shows no fluorescein leakage and hypofluorescence at the optic disc pit.

1.2. Ocular pathologies

1.2.1. Posterior precortical vitreous pocket (bursa premacularis)

A posterior precortical vitreous pocket (PPVP) is a liquefied lacuna located anterior to the macular area that is present in the vitreous of normal adults.[25] Worst[26,27] described the bursa premacularis as a pear-shaped sac with its own outer membrane, which was observed by injecting India ink into the vitreous of *postmortem* eyes. Kishi and Shimizu[25] described PPVPs in autopsy eyes, which were made visible by staining with fluorescein dye. The PPVP was considered to be the same space as the bursa premacularis except that there was no membrane but a layer of premacular cortical vitreous that adhered to the macula in young adults. PPVPs have also been identified as a dome-shaped space above the macula that can be observed during triamcinolone acetonide-assisted vitreous surgery and SD-OCT.

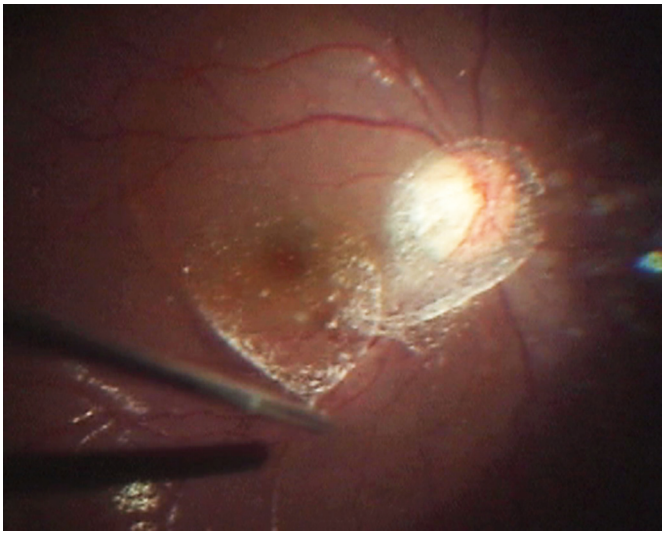

Fig. 2. Intraoperative photograph of the patient shown in Figure 1. White triamcinolone crystals can be seen in the posterior precortical vitreous pocket above the macula and Cloquet's canal above the optic disc.