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Case Report

Comparison of Spectral-Domain and Time-Domain Optical Coherence Tomography in Solar Retinopathy

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The purpose of this article is to compare spectral-domain (SD) and time-domain (TD) optical coherence tomography (OCT) findings in patients with solar retinopathy. Complete ocular examinations and OCT were performed in two patients presenting with acute solar retinopathy soon after observation of an eclipse. Both patients were evaluated with SD-OCT and TD-OCT at the same time. SD-OCT demonstrated characteristic defects at the level of the inner and outer segment junction of the photoreceptors in all the affected eyes and decreased reflectiveness of the retinal pigment epithelium layer. TD-OCT images showed unremarkable findings in two eyes with deteriorated visual acuity. SD-OCT improves diagnosis and assessment of the degree and nature of foveal damage in patients with solar retinopathy and may be an important tool for use in identifying foveal damage not detected by TD-OCT. SD-OCT may be preferable to TD-OCT for confirmation or assessment of the degree of foveal damage in patients with solar retinopathy.

Key Words: Optical coherence tomography, Retinal disease, Solar energy

Solar retinopathy is a clinical entity that occurs as a result of retinal damage secondary to direct or indirect viewing of the sun. The most common cause of solar retinopathy is direct viewing of a solar eclipse without protective gear [1].

Bechmann et al. [2] were the first to demonstrate optical coherence tomography (OCT) findings for solar retinopathy, including hypo- or hyperreflective lesions of the retinal pigment epithelium (RPE) and outer retina. OCT findings are a more reliable tool than fluorescein angiography (FA) for identifying foveal damage in patients with solar retinopathy [3].

Several types of spectral-domain (SD)-OCT machines have recently been introduced to ophthalmic clinical practice. Time-domain (TD)-OCT technology allows visualization of anatomic structures within the eye to about 10 μm; SD-OCT technology allows visualization to nearly 3 μm. In addition, whereas TD-OCT images are acquired at a rate of approximately 400 scans per second, SD-OCT technology allows image acquisition to occur at about 20,000 to 40,000 scans per second, facilitating accurate and reproducible acquisition of images. TD-OCT captures only a limited representative area of the macula, which may not show macular pathology [4]. We describe our comparison of SD-OCT and TD-OCT findings for two eyes of two patients with a diagnosis of solar retinopathy.

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Case Reports

Case 1

A 21-year-old man came to our attention two days after a solar eclipse, reporting a small central scotoma and blurred vision in the right eye while reading. He said he had watched the sun continuously, for about one minute, during the eclipse, using only sunglasses for protection. He said he used no systemic or topical drugs and had no ocular trauma or medical history. His visual acuity was 20 / 30, not better with correction in the right eye, 20 / 20 without correction in the left eye. A central scotoma of the right eye was noted on the Amsler grid test. The anterior segment in each eye was unremarkable. Fundus examination revealed an alteration in the foveal reflex in the right eye. A yellowish-white spot was observed in the foveal area in the right eye, the right eye being his dominant eye. Fundus examination of the left eye was

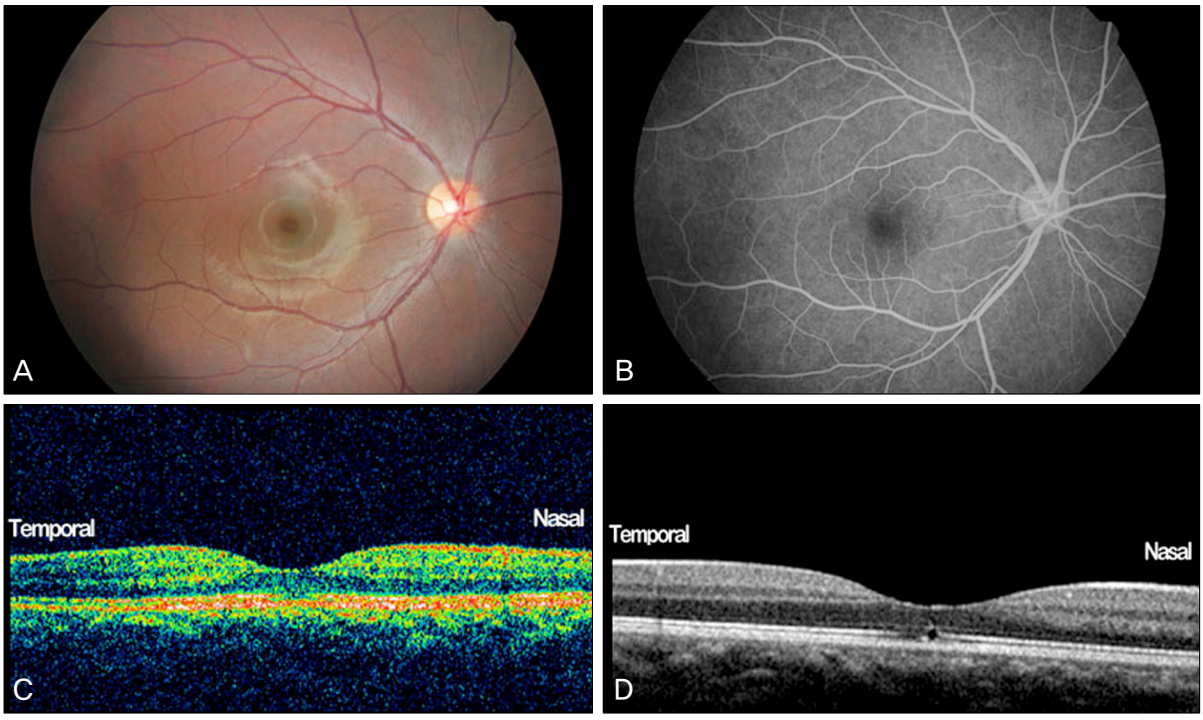

Fig. 1. (A) Fundus photograph of the right eye in case 1 showing a small hypopigmented lesion in the fovea. (B) Fluorescein angiogram of the right eye of the same patient showing unremarkable findings. (C) Time-domain optical coherence tomography (OCT) through the fovea of the right eye of the same patient showing the smallest possible abnormality of the inner hyperreflective layer. (D) Spectral-domain-OCT of the same patient confirmed more clearly the disruption of the inner segment and outer segment line, and decreased intensity of the reflectiveness of the retinal pigment epithelium at the fovea.

unremarkable. No alteration was seen in either eye using FA. TD-OCT (Stratus OCT; Carl Zeiss Meditec Inc., Dublin, CA, USA) and SD-OCT (Spectral OCT/SLO; OTI Ophthalmic Technologies Inc., Miami, FL, USA) were used for macular scanning. TD-OCT examination revealed a minimal abnormality of the inner thin hyperreflective layer (HRL), corresponding to the junction between the inner and outer photoreceptor segments at the fovea. However, SD-OCT captured more clearly a disrupted inner segment and outer segment (IS/OS) line, as well as decreased intensity of the reflectiveness of the RPE in the foveolar area of the right eye (Fig. 1). The left eye appeared normal on TD-OCT and SD-OCT. After 4 months, the patient reported an improvement in his vision; however, the central scotoma remained. Best corrected visual acuity of the right eye was 20 / 25, and the yellowish-white spot was still in the foveolar area of the right eye; however, it was smaller than before.

Case 2

A 10-year-old boy came to our attention one day after a solar eclipse, reporting blurred vision in the left eye. He said he had watched the sun continuously, for about 30 seconds, during the eclipse, without any protection. He had no ocular trauma or medical history. His best corrected visual acuity was 20 / 25 in the left eye, and 20 / 20 in the right eye. No alterations were noted bilaterally on the Amsler grid test. The anterior segment in each eye was unremarkable. Fundus examination revealed a small yellowish-white spot in the foveal area of the left eye. Fundus examinations of the right eye were unremarkable. The left eye was his dominant eye. No alteration was observed in either eye using FA. TD-OCT examination revealed unremarkable findings; however, SD-OCT captured a small but significant disrupted IS/OS line in the foveolar area of the right eye, and decreased reflectiveness of RPE (Fig. 2). The right eye appeared to have normal findings on TD-OCT and SD-OCT. After five months, the patient reported an improvement in his vision. The best corrected visual acuity of the left eye was 20 / 20.

Discussion

In solar retinopathy, photochemical damage mediated by highly reactive free radicals is believed to be the predominant mechanism of retinal injury; Gass [5] postulated that blue wavelengths of light are chiefly responsible for the production of this photochemical injury, which manifests as damage to the apical melanosomes of the RPE. This is followed by disruption of photoreceptors. Pathologic changes are largely confined to the outer segments of the photoreceptor in the fovea, with fine structural anomalies in the RPE layer that may lead to depigmenation [6].

Current understanding of the pathophysiology of solar retinopathy is in line with OCT images. TD-OCT reports of

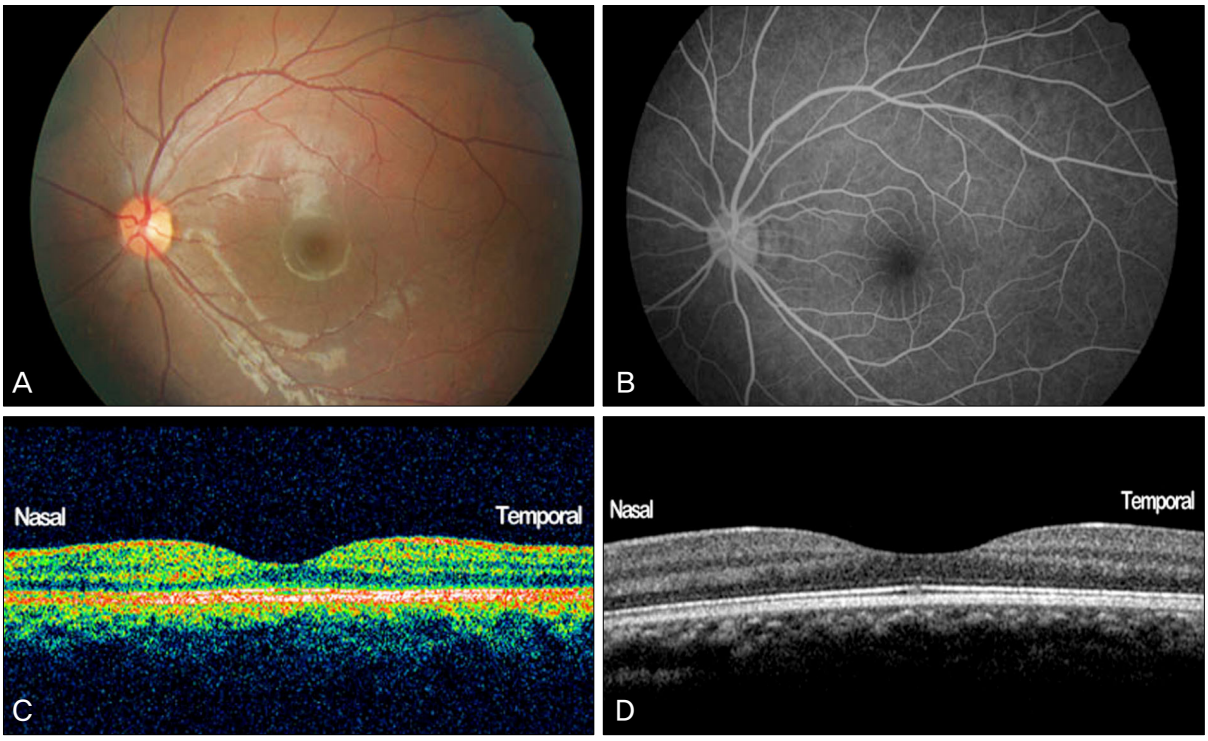

Fig. 2. (A) Fundus photograph of the left eye in case 2, showing unremarkable findings. (B) Fluorescein angiography of the same patient showing unremarkable findings. (C) Time-domain-optical coherence tomography (OCT) through the fovea of the left eye of the same patient showing unremarkable findings. (D) Spectral-domain-OCT of the same patient revealed a small disruption of the inner segment and outer segment line, and decreased intensity of the reflectiveness of the retinal pigment epithelium at the fovea.

acute solar retinopathy indicate a predominance of outer HRL damage with minimal or no inner HRL damage [7]. The superficial inner thin HRL of TD-OCT represents the junction between the inner and outer photoreceptor segments, and the deeper thick outer HRL represents RPE. In the acute stage of solar retinopathy, input of irradiation is absorbed preferentially by melanosomes in the RPE. Defects of the outer HRL may correspond to necrotic PRE and loss of melanin granules [6]. With prolonged exposure, the damage may extend to involve the outer segments of the photoreceptor, perhaps through thermal mechanisms, which is consistent with the inner HRL defect found on the TD-OCT.

To the best of our knowledge, in most previous reports, TD-OCT alone was used for evaluation of solar retinopathy. Despite the remarkable clinical utility of TD-OCT, it also has limitations. TD-OCT is limited by axial resolution (10 μm), image acquisition speed, and a small number of scans. Limitations of TD-OCT may result in sampling errors, and may lead to missed areas of pathology due to incomplete scanning of the macular [4]. In fact, in our cases, TD-OCT missed or did not show the precise pathology of the macula. When damage to the retina in solar retinopathy was limited to the outer segments of the photoreceptors, and changes were minute, TD-OCT may have missed the pathology.

In Case 2, SD-OCT showed a significantly small disrupted IS/OS line and abnormal hyperreflectivity outer segments of photoreceptors in the foveolar area. This finding suggests that outer segments of photoreceptors and the associated RPE layer were the site primary affected with acute solar retinopathy

In conclusion, in two eyes with solar retinopathy, we demonstrated that SD-OCT may be preferable to TD-OCT for demonstration and diagnosis of solar retinopathy. When a patient's history of sungazing is difficult to elicit, or in cases with unremarkable findings from other ocular examinations, despite sungazing history, SD-OCT imaging will assist in the diagnosis of this unique retinal condition, particularly in the early stage, or in patients with minimal change.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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