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# High-definition optical coherent tomography findings in acute solar retinopathy – a case series

## *Optyczna koherentna tomografia wysokiej rozdzielczości we wczesnej retinopatii słonecznej – opis serii przypadków*

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### Summary:

The paper reports the case series of solar retinopathy. High definition optical coherence tomography examinations performed within 2 days after solar light-induced injury indicated a characteristic retinal disorder – a curved, hyper-reflective lesion extending from the retinal pigment epithelium at the fovea to the parafoveal outer plexiform layer. The findings correspond to the layout of photoreceptor cells whose injury in patients with solar retinopathy is confirmed by histological studies reported in available publications.

### Key words:

solar retinopathy, eclipse of the sun, light-induced injury, optical coherence tomography (OCT), phototoxicity, photoreceptor.

### Streszczenie:

Opis serii przypadków retinopatii słonecznej. W badaniach optycznej koherentnej tomografii wysokiej rozdzielczości wykonanych u 5 pacjentów (8 oczu) do 2 dni od ekspozycji na światło słoneczne zaobserwowano charakterystyczne zaburzenie siatkówki – hiperrefleksyjna zmiana przebiegała łukowato od nabłonka barwnikowego siatkówki w dołku do okołodołkowej warstwy spłotowatej zewnętrznej. Odpowiada to układowi komórek fotoreceptorowych, których uszkodzenie w przebiegu retinopatii słonecznej potwierdzają wyniki badań histopatologicznych dostępne w literaturze medycznej.

### Słowa kluczowe:

retinopatia słoneczna, zaćmienie słońca, uraz świetlny, optyczna koherentna tomografia (OCT), fototoksyczność, fotoreceptor.

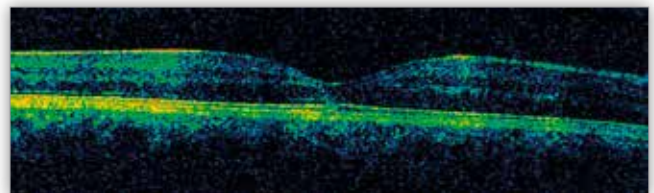
Partial solar eclipse was observable from the territory of Poland on 20 March 2015. In Wrocław it was visible from about 9:40 a.m. till 12:00 noon, with the zenith at 10:50. Throughout the eclipse, the sky was almost cloudless, which, along with the peak positioning of the sun, was conducive to the solar radiation reaching the surface of the Earth.

Within the following four days, five patients reported to the A&E of the 4<sup>th</sup> Military Clinical Hospital with Polyclinic in Wrocław, and solar retinopathy was diagnosed in a total of 8 eyes. The diagnosis was based on thorough history positive for gazing at the sun during the eclipse, patient-reported symptoms and dilated fundus exam. In most cases, the diagnosis was confirmed with the HD-OCT (Cirrus HD-OCT 5000, Carl Zeiss Meditec). Three patients (6 eyes) reported for the follow-up appointment 3–4 weeks later.

### Case 1 (Fig. 1)

A 32-year-old man reported to the A&E a few hours after the solar eclipse which he had observed through sunglasses. He reported persistent scotoma in the visual field of his right eye. The best corrected visual acuity determined using the Snellen chart was 0.9 and 1.0 in his right (RE) and left eye (LE), respectively. No significant abnormalities were found within the anterior segment and the fundus of the RE.

The patient was lost to follow-up.



**Fig. 1.** HD-OCT of the macula. Case 1, right eye. The picture shows hyperreflective curved lesion extending from the retinal pigment epithelium at the fovea to the parafoveal outer plexiform layer.

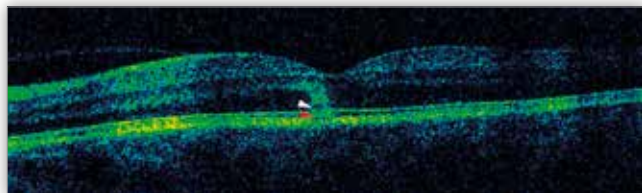
**Ryc. 1.** HD-OCT plamki. Przypadek 1., oko prawe. Widoczna hiperrefleksyjna zmiana o łukowatym przebiegu między nabłonkiem barwnikowym siatkówki w dołku a okołodołkową warstwą spłotowatą zewnętrzną.

### Case 2 (Fig. 2)

A 54-year-old man reported to the A&E one day after observing the solar eclipse. He gazed at the sun mostly with his left eye a few times for a dozen or so seconds with his eyes unprotected. On admission, he reported vision impairment in his LE and denied any previous problems with his eyesight. The uncorrected visual acuity in his RE was 0.9 and did not improve with correction, whereas in the LE it was 0.1, improving to 0.3 with correction (-0.5 Dsph -0.75 Dcyl ax 100). Physical examination of the RE, as well as of the anterior segment of the LE

did not show any abnormalities. Yet, in the left macula, a small, pale lesion, located in the parafoveal area was observed.

The patient was lost to follow-up.



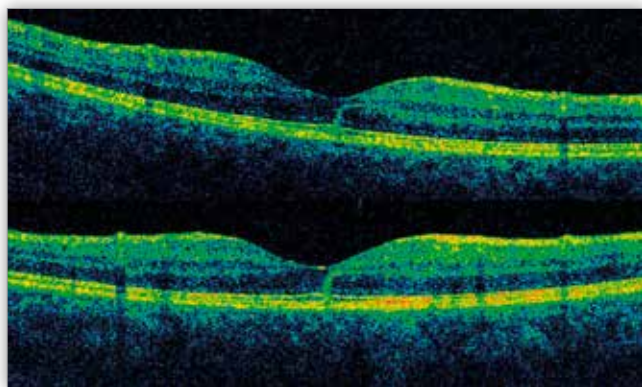
**Fig. 2.** HD-OCT of the macula. Case 2, left eye. The lesion is similar to that described under Figure 1. Additionally, there are hyporeflective spaces within the myoid zone of the photoreceptor (white arrow) and interdigitation zone (red arrow).

**Ryc. 2.** HD-OCT plamki. Przypadek 2., oko lewe. Zmiana podobna do zmiany opisanej na rycinie 1. Ponadto hyporefleksyjne przestrzenie w zakresie strefy mioidalnej wewnętrznych segmentów fotoreceptorów (biały grot) oraz strefy ząbkowania fotoreceptorów i nabłonka barwnikowego siatkówki (czerwony grot).

**Case 3 (Fig. 3)**

A 26-year-old woman reported a impaired visual acuity and a tiny persistent scotoma in her both eyes. One day earlier, she had been gazing at the solar eclipse for approx. 1 minute with her eyes unprotected. She denied having had any earlier eye problems. Refraction testing showed the following: RE -0.5 Dsph -0.5 Dcyl ax 98 and LE -0.75 Dsph. The BCVA and UCVA were 0.6 and 1.0 in the RE and LE, respectively. The anterior and posterior segments of both eyes appeared normal.

During the follow-up appointment, the patient reported vision improvement in both eyes. The BCVA and UCVA was 1.0 bilaterally. The Amsler grid test indicated the presence of paracentral scotoma. However, no ocular abnormalities were shown in ophthalmoscopy.



**Fig. 3.** HD-OCT of the macula. Case 3, right eye (top) and left eye. The lesions are similar to those described under Figure 1.

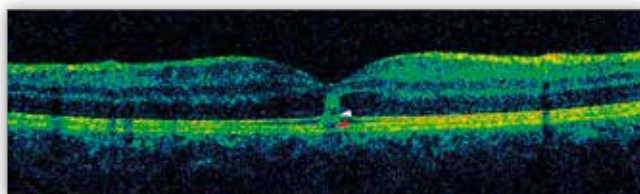
**Ryc. 3.** HD-OCT plamki. Przypadek 3., oko prawe (u góry) i lewe. Zmiany podobne do zmian opisanych na rycinie 1.

**Case 4 (Fig. 4)**

A 16-year old boy reported to the A&E with a central scotoma and vision impairment in the right eye one day after the solar eclipse. He had gazed at the eclipse for a few seconds with his eyes unprotected. In 2009 he had suffered a head injury which caused optic nerve atrophy in the left eye. Medical records provided by the parents proved that the uncorrected and best corrected visual acuity remained unchanged between 2012 and 2014 amounting to 1.0 in his RE and hand movement

(HM) in the LE. Upon admission, though, the BCVA in the RE was 0.1 and HM in the LE (refraction: RE +0.25 Dsph, LE +0.25 Dsph -0.5 Dcyl ax 145). The anterior segment of the RE did not show any abnormalities. However, ophthalmoscopy revealed mild macular oedema and the patient was administered 40 g methylprednisolone in a peribulbar injection into his RE (Depo-Medrol 40 mg/ml).

During the follow-up examination, the BCVA and UCVA was 0.8 in the RE and HM in the LE. The patient reported vision improvement in his RE. In brightly lit rooms (not in Amsler grid, though) the presence of paracentral scotoma in the visual field of the RE was detected, which did not interfere with his usual functioning. The examination of the anterior segment of the RE and LE showed no abnormalities, and both maculas were red.



**Fig. 4.** HD-OCT of the macula. Case 4, right eye. The lesions resemble those described under Figure 2.

**Ryc. 4.** HD-OCT plamki. Przypadek 4., oko prawe. Zmiana podobna do zmiany opisanej na rycinie 2.

**Case 5 (Fig. 5)**

Three days after sun gazing during the solar eclipse, a 24-year-old patient presented with a persistent scotoma in the visual fields of both eyes. He observed the sun for the total time of 2 minutes (a few times for a dozen or so seconds) and he used sunglasses. He denied any previous vision problems. The UCVA was 0.8 and 0.6 in the RE and LE, respectively. The refraction was +0.25 Dsph and +0.25 Dsph -0.5 Dcyl ax 83 in the RE and LE, respectively. Funduscopy revealed a reduced macular reflex, as well as minor pigment regrouping in both maculas. No abnormalities were shown within the anterior segments of both eyes.

The BCVA and UCVA assessed during the follow-up appointment were 1.5 for the RE and the LE. The patient reported a small paracentral scotoma and slight image blurring in the centre of vision field which interfered reading. Even though, he had a full near visual acuity in both eyes. Again, no abnormalities were revealed within the anterior segments of both eyes, but within the parafoveal areas of both eyes the identical, small, clearly demarcated red lesion was seen.

**Discussion**

In all patients who had OCT performed within 2 days following solar light induced injury (cases 1–4) a characteristic retinal abnormality was found presenting as a hyperreflective lesion extending archwise from the retinal pigment epithelium (RPE) in the fovea to the parafoveal outer plexiform layer (OPL). Furthermore, in patients 2 and 4 small hyporeflective spaces were visible within the retinal lesion, in the myoid zone of the photoreceptors (MZ), in photoreceptor peaks and the RPE cone interdigitation zone (IZ) (Fig. 1–4).

The follow-up OCT examination (Fig. 5) showed no abnormalities of inner retina in all the patients. In the outer retina the-

re were some minor persistent abnormalities with respect to IZ (Case 3) or an observed hyporeflective zone encompassing to a various degree MZ, the ellipsoid zone of the photoreceptors (EZ), the layer of outer segments of the photoreceptors (OS) as well as IZ (Case 4 and 5).

Interestingly, the lesions were bilateral in one patient (Case 4) despite a considerable vision impairment in the LE due to a former head injury. This suggests that the fixation of the eye with better visual acuity, correct positioning of the eyeballs, adequate refraction and clear optic media are sufficient prerequisites for solar retinopathy.

Hope-Ross et al. (1) studied histology of the retina after light-induced injury in a patient whose eye had been enucleated due to melanoma. Six days earlier he was asked to gaze at the sun for 10 minutes. It was proved that the photochemical damage mostly affects mitochondria located in inner segments as well as the cell membrane of outer photoreceptor segments. The rods in the parafoveal area were shown to be particularly susceptible to permanent damage manifesting as obvious nuclear pyknosis (shrinkage) and mitochondrial swelling, whereas the cones in the foveal and parafoveal area proved to be relatively

resistant to photochemical damage, which is why patients with solar retinopathy usually maintain good visual acuity. Solar retinopathy affects the RPE to the variable extent (1, 2). Considerably small injuries are compensated by pigment regrouping. The restoration of the phagocytic function of RPE cells and the regeneration of photoreceptor outer segments can also contribute to the spontaneous improvement in visual acuity.

The authors of papers on OCT findings in acute solar retinopathy reported lesions in the outer retinal layers, without indicating any irregularities within the inner retina or focusing on its hyperreflectivity (3–10). The HD-OCT enables a more thorough analysis as it penetrates deeper into retinal ultrastructure. The observations we performed in the first several dozen hours since the onset of RS clearly indicate that the process affects the structures located between the RPE of the fovea and the parafoveal OPL. This corresponds to the location of macular photoreceptors suggesting that they are the main site of the actual functional or structural damage caused by solar light-induced injury. The findings of histological studies referred to above are compatible with the HD-OCT images obtained in our research.

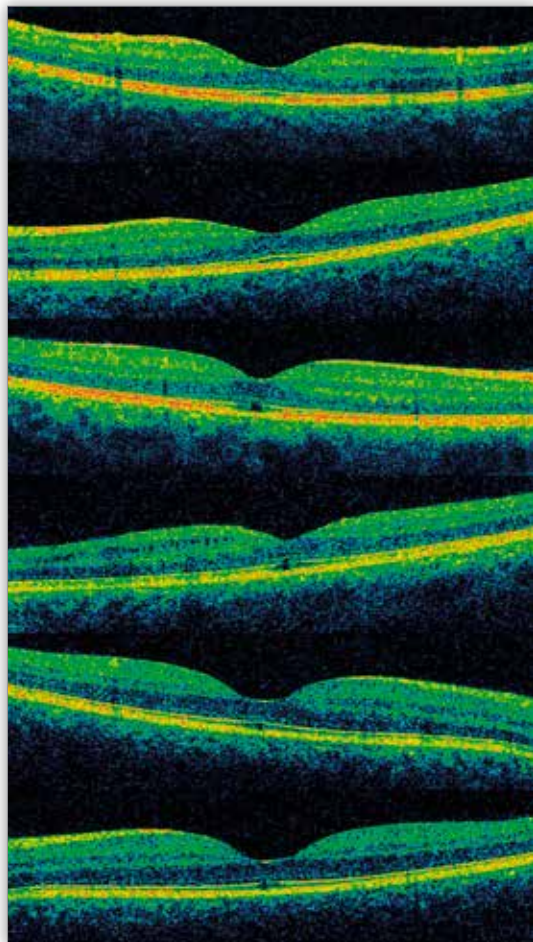
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**Fig. 5.** HD-OCT of the macula. Follow up examination 3 weeks after light-induced injury. From the top: Case 3 – right eye and left eye, Case 4 – right eye and left eye, Case 5 – right eye and left eye. See the body of the article for a detailed description.

**Ryc. 5.** HD-OCT plamki. Badanie kontrolne po 3 tygodniach od doznania urazu światłem. Kolejno od góry: przypadek 3. – oko prawe i oko lewe, przypadek 4. – oko prawe i oko lewe, przypadek 5. – oko prawe i oko lewe. Opis w tekście