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Extrafoveal Photostress Recovery Testing With a Scanning Laser Ophthalmoscope

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Abstract: We used a modified photostress recovery test (PSRT) with microperimetry in a scanning laser ophthalmoscope (SLO) to evaluate the extrafoveal region. After the red-target threshold was determined, the retina was bleached with argon green laser illumination. Test spots were presented every 3 seconds at the testing point and subjects indicated when they saw the spot. We determined the recovery time in 17 normal subjects under the following conditions: bleaching times of 10, 20, and 30 seconds; spot intensities of 0, 2, and 4 dB greater than threshold; Goldmann I, II, and III spots; and spot locations 7.5° temporal to, nasal to, above and below the fovea, and at the fovea. We also measured recovery times inside and outside the detachment in 11 patients with central serous chorioretinopathy. Recovery time was correlated with bleaching time and spot intensity, but not with the location of spot size in normal subjects. In patients with chorioretinopathy, the recovery time was longer inside than outside the detachment. This technique is useful for measurement of photostress recovery time at extrafoveal points, and for comparison of times at various testing points. Results in patients with chorioretinopathy suggest that this technique may be useful for studying the pathophysiology in ocular diseases. **Jpn J Ophthalmol 1997;41:255–259** © 1997 Japanese Ophthalmological Society

Key Words: Central serous chorioretinopathy, extrafoveal photostress recovery test, microperimetry, scanning laser ophthalmoscope.

Introduction

The photostress recovery test (PSRT), which measures time-to-recovery of the light threshold after bleaching,[1–5] is used to evaluate retinal function. The time is prolonged in patients with central serous chorioretinopathy,[1] age-related macular degeneration,[6] diabetic retinopathy,[7] and Anandron[8] or digitalis[9] toxicity. Recovery time is mainly determined by cone pigment regeneration. Sherman and Henkind[10] reported that patients with glaucoma showed prolongation of the recovery time, suggesting that a ganglion cell abnormality may delay recovery or that glaucoma may cause cone pigment abnormality. PSRTs can be done with an acuity chart (conventional PSRT),[1–5] a pattern VEP (VEP PSRT),[11–13] or a pupillometer (pupil PSRT).[14] Conventional and VEP PSRTs measure macular function and the pupil PSRT tests the central 30° of the visual field. We investigated the usefulness of PSRT, using microperimetry with a scanning laser ophthalmoscope (SLO) to measure recovery time in the extrafoveal area. This test can be easily done with a commercially available SLO and a Wratten filter.

Subjects and Methods

Seventeen normal subjects (10 men, 7 women; 25–40 years old; refractive error: −5.0–0 diopters) and 11 patients with central serous chorioretinopathy were involved in this study. The normal subjects had no ocular diseases; patient details are shown in Table 1. Prior to testing, written informed consent was obtained from the subjects.

After subjects' pupils were dilated with a combination of 0.5% tropicamide and 0.5% phenylephrine hydrochloride, the subjective threshold for the red target was measured by microperimetry with SLO (Scotometry 1.1, Rodenstock, Germany) at selected testing points. Recovery time was defined as the

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Table 1. Characteristics of Patients With Central Serous Chorioretinopathy

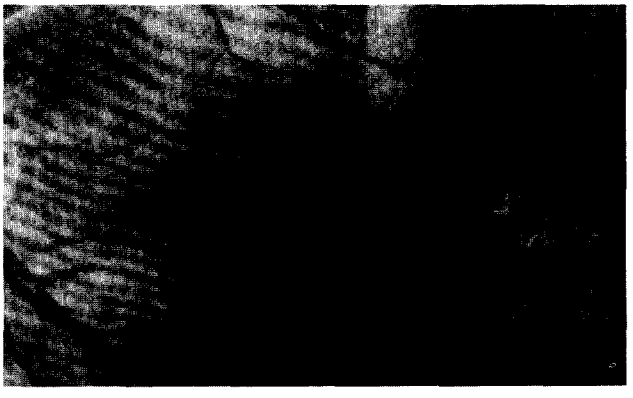
	Age	Sex	Visual Acuity	Threshold (dB)		Recovery Time (seconds)	
				Outside RD	Inside RD	Outside RD	Inside RD
Case 1	44	M	0.6	15	11	39	179
Case 2	32	M	1.0	17	5	36	219
Case 3	40	M	0.9	17	14	59	95
Case 4	45	F	0.5	16	5	66	53
Case 5	52	F	0.9	15	14	61	61
Case 6	54	F	0.9	19	19	67	67
Case 7	44	M	1.0	20	18	21	130
Case 8	68	F	0.9	19	18	126	128
Case 9	51	M	1.2	21	21	31	33
Case 10	53	M	0.6	19	15	103	109
Case 11	40	M	0.5	19	19	91	210
Mean						60.7	117.2*
SD						32.2	63.6

RD: retinal detachment.
*$P = 0.032$ vs outside RD.

time from the end of bleaching to recognition of the red test spot. We used Goldmann I, II, and III spots with a background illumination of 10 cd/m^2. The test spots, background illumination, and a fixating point were 633 nm in wavelength from a He-Ne laser. After subjects were dark-adapted for 15 minutes, argon green illumination (argon green 9; wavelength, 514 nm; intensity, 4.7 log cd/m^2) was projected onto the fundus. This illumination was superimposed on the background illumination of 10 cd/m^2 and the fixating point in the microperimetry.

When measuring recovery time at the extrafoveal points, we bleached only the area of the testing point, leaving the fovea unbleached so that the subjects saw the central fixating point during and after bleaching. For example, when testing the temporal area in the left eye, the right side of the instrument window of the SLO was covered with a Wratten 21 filter that absorbed all light below 520 nm wavelength. This filter blocked the bright green illumination (514 nm) that was bleaching the nasal side and the fovea in the right eye, but did not prevent the subject from seeing the red background illumination and the 633 nm fixating point (Figure 1A).

When testing the fovea, we bleached only the central area that included the fovea, leaving the extrafoveal area unbleached by the filter on the instrument window of the SLO. Four fixating points were placed in the unbleached area and the subjects were asked to focus on the center of these points during and after bleaching (Figure 1B). This technique reduces the amount of light entering the eye, minimizing the subjects' discomfort and resulting in consistent measurements. As soon as bleaching was



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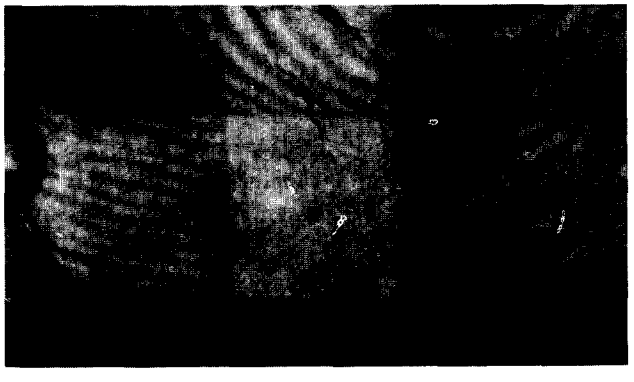

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Figure 1. (**A**) SLO monitor view of fundus with argon laser-bleached temporal area. Nasal area, including fovea, was not bleached because of filter (Wratten 21) on SLO window. Subject could see fixation point. + indicates fixation target. A indicates testing point. (**B**) Fundus view with argon laser-bleached central area. The peripheral area was not bleached. Subjects could see four fixation points. + indicates extrafoveal fixation targets. A indicates testing point.

completed, the test spot was presented every 3 seconds on background illumination of 10 cd/m^2. When subjects located the red test spot, they pressed a button. The fundus was monitored during all procedures so that the fixation could be confirmed.

Tests on Normal Subjects

1. To determine the effect of the bleaching time, the temporal retina was bleached for 10, 20, and 30 seconds; recovery time was measured with a Goldmann I test spot and intensity 2 dB greater than threshold. The testing point was 7.5° temporal to the fovea.
2. To determine the effect of test spot size, recovery time after 20 seconds of bleaching was measured using Goldmann I, II, and III test spots and intensity 2 dB greater than threshold. The testing point was 7.5° temporal to the fovea.
3. To determine the effect of test spot intensity, recovery time after 20 seconds of bleaching was measured using a Goldmann I test spot and intensities 0, 2, and 4 dB greater than threshold. The testing point was 7.5° temporal to the fovea.
4. To determine the effect of test spot location, recovery time was measured at points 7.5° temporal to, nasal to, above and below the fovea, and at the fovea using a Goldmann I test spot, intensity 2 dB greater than threshold, and a bleaching time of 20 seconds.

To validate this test, recovery time was measured at extrafoveal points inside and outside the detachment in 11 patients with central serous chorioretinopathy using a red test spot, Goldmann I spot size, and an intensity 2 dB greater than threshold after 20 seconds of bleaching. Data for these patients are shown in Table 1.

Results

Bleaching Time

Recovery times after bleaching of 10, 20, and 30 seconds were 29.5 ± 8.5, 40.6 ± 8.1, and 45.2 ± 12.7 (mean ± SD) seconds, respectively (Figure 2A). It was significantly longer after 20 seconds than after 10 seconds (paired t-test, $P = 0.0005$). There was no significant difference in recovery times between 20 and 30 seconds (paired t-test, $P = 0.14$). Some subjects reported discomfort after 30 seconds, perhaps resulting in a larger standard deviation.

Size

Recovery times with Goldmann test spots I, II, and III were 40.6 ± 8.1, 42.4 ± 15.8, and 45.4 ± 15.5 (mean ± SD) seconds, respectively (Figure 2B). There was no statistically significant difference (ANOVA; $F(2,32) = 1.3$; $P = 0.29$). Test spot size had no significant effect on recovery time. Red spot threshold was 16.6 ± 0.8 dB with a Goldmann I spot; 21.3 ± 1.2 dB with a Goldmann II spot, and 23.0 ± 1.2 dB with a Goldmann III spot. Larger spot sizes produced significantly lower thresholds (paired t-test, $P < 0.0001$; Goldmann I/II, II/III, I/III).

Intensity

Recovery times with spot intensities of 0, 2, and 4 dB greater than threshold were 81.3 ± 23.9, 40.6 ± 8.1, and 23.1 ± 6.3 (mean ± SD) seconds, respectively (Figure 2C). It decreased significantly with increased intensities (paired t-test; $P < 0.0001$; 0/2 dB, 2/4 dB, 0/4 dB). Some subjects reported that it was difficult to detect the spot after bleaching; this produced the largest standard deviation.

Location

Recovery times at spots 7.5° temporal to, nasal to, above and below the fovea, and at the fovea were 40.6 ± 8.1, 37.6 ± 13.4, 42.1 ± 7.7, 38.6 ± 7.8, and 37.9 ± 18.4 (mean ± SD) seconds, respectively (Figure 2D). There was no significant difference (ANOVA; $F(4,64) = 0.53$, $P = 0.71$). The test point location did not influence the recovery time. Red spot threshold was 16.6 ± 0.8 dB at the temporal point, 16.7 ± 1.8 dB at the nasal point, 16.0 ± 0.94 above the fovea, 16.2 ± 1.9 dB below the fovea, and 20.6 ± 1.2 dB at the fovea. The threshold was significantly lower at the fovea than at other testing points (paired t-test; $P < 0.0001$ fovea/temporal, fovea/nasal, fovea/below, fovea/above).

Table 1 shows threshold and recovery times inside and outside the lesion in patients with central serous chorioretinopathy. These were 116.7 ± 63.7 and 63.6 ± 32.4 (mean ± SD) seconds. Recovery time was significantly longer inside the detachment than outside (paired t-test; $P = 0.032$). This result is in accord with a previous report.[1]

Discussion

The PSRT is useful for evaluation of macular function. Recovery time is chiefly determined by cone pigment regeneration at the fovea, although it may be slightly influenced by glaucoma. Foveal cone regeneration can be measured with a cone densitometer, but this device is complex and not commercially available. One advantage of conventional PSRT is that it requires only an acuity chart and a source of

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bleaching light. However, conventional PSRT does not assess the extrafoveal area. Fundus refractometry with an SLO and a yellow laser can be used for testing the cone pigment of the extrafoveal area, but this system is also not commercially available.[15] We modified the PSRT using microperimetry with an SLO in an attempt to measure recovery time in the extrafoveal area. Although SLOs are expensive, they are widely available. The SLO permitted monitoring of the fundus during all procedures and confirmation of test spot location. During bleaching, the SLO allowed us to verify that the area of the testing point was bleached and that the test spot was placed at the testing point.

One difference between the test used in the present study and conventional PSRT is the use of a red test spot instead of an acuity chart. The cone system mediates both detection of the red spot and the reading of the acuity chart; therefore, recovery times measured by conventional PSRT and by our test both depend on cone pigment regeneration. In measuring recovery time at extrafoveal points, we left the fovea unbleached because bleaching made the central fixating point difficult to see, causing eye movements that yielded inconsistent results. Eliminating eye movement is essential when evaluating extrafoveal regions.

We tested normal subjects to determine the effects

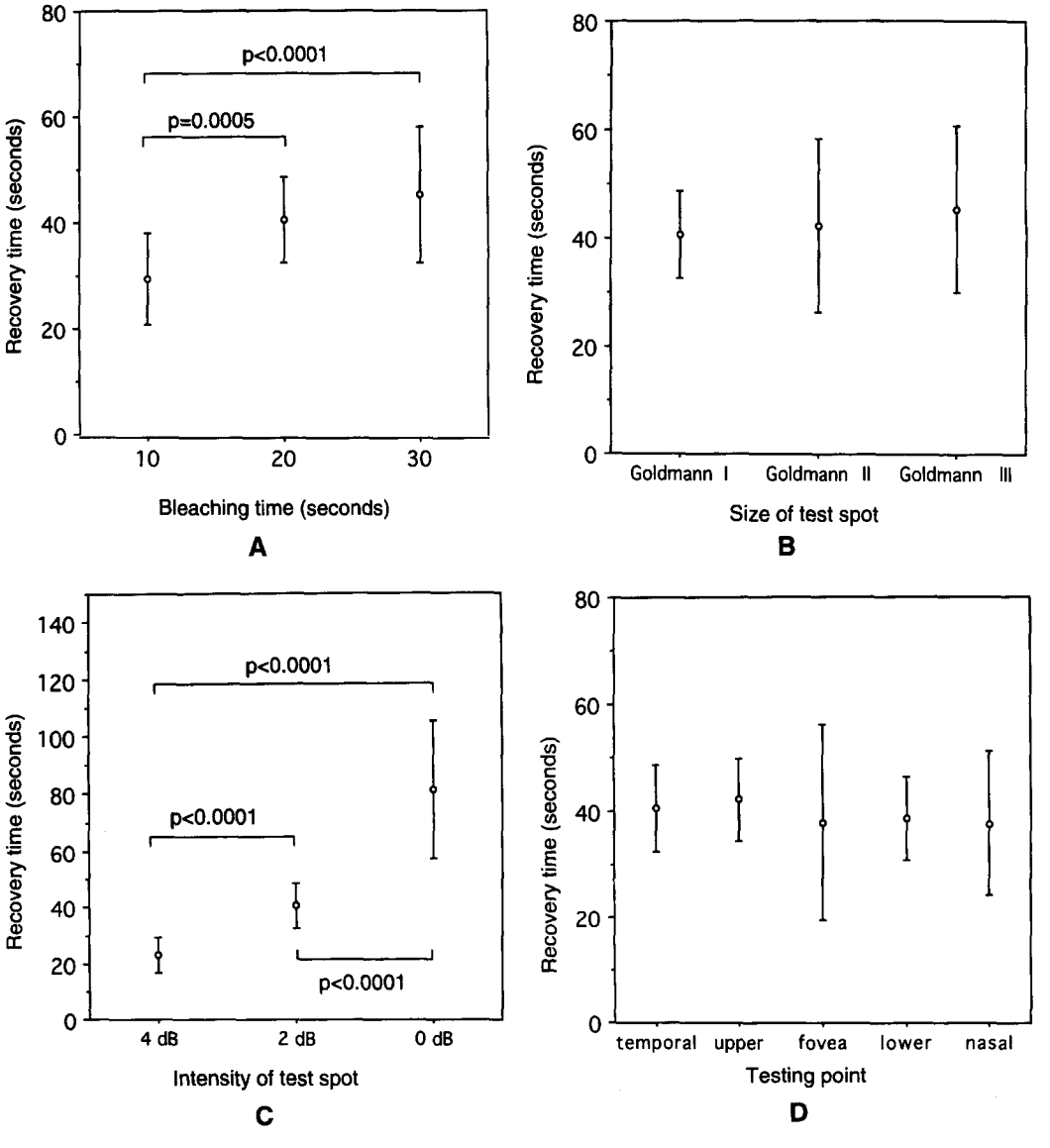

Figure 2. (**A**) Effect of bleaching time on recovery time. (**B**) The effect of test spot size on recovery time. (**C**) The effect of test spot intensity on recovery time. (**D**) The effect of test spot location on recovery time.

of testing conditions on PSRT with an SLO. The recovery time was near maximum after 20 seconds of bleaching, suggesting that maximum bleach with the green light can be obtained after 20 seconds. Villermet and Weale[16] suggested that the bleaching energy for a "clearing bleach" is 7.0 log trolands for 30 seconds; we found that the longer bleaching time caused discomfort and resulted in a larger standard deviation. Therefore, we advocate that the retina be bleached for only 20 seconds when this test is used clinically. Spot size did not influence recovery time. In patients with a severely damaged retina who cannot detect a small test spot, we must use the larger size for measuring PSRT. Present results indicate that results obtained with a larger spot are comparable to those obtained with a smaller spot. Recovery time decreased at increasing spot intensities, indicating that accurate measurement of the threshold is necessary for this test. If the threshold is underestimated, the recovery time will also be underestimated. A large standard deviation found with a spot at threshold intensity suggests that the intensity of the test spot should be higher than the threshold. Test spot location did not influence recovery time, suggesting that recovery time determined with an SLO is consistent at all fundus points.

Recovery time was significantly longer inside than outside the detachment in the 11 patients with central serous chorioretinopathy, consistent with a previous report[1] and suggesting that our technique can be used in patients with various ocular diseases affecting retinal outer layers.

Our findings also suggest that the modified PSRT is useful for evaluation of cone pigment regeneration in extrafoveal lesions. Although we used an SLO for this test, any fundus camera or apparatus that can measure the subjective threshold while monitoring the fundus could be used. Because the SLO was not designed for this purpose, there are several limitations associated with its use. For example, the bleaching light cannot be turned on and off automatically, but must be operated manually in steps requiring several seconds, and the colors of the test spot and bleaching light are not identical. Resolution of these problems would improve the usefulness of this technique. Even with the current limitations, however, we can easily use this method with a commercially available SLO and a Wratten filter, producing a technique that is very useful for diagnosis and study of diseases of the outer retina.

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