Scotoma Size and Reading Speed in Patients with Subfoveal Occult Choroidal Neovascularization in Age-related Macular Degeneration

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Purpose: To investigate the correlation between reading speed and scotoma size in patients with subfoveal occult with no classic choroidal neovascularization (CNV) in age-related macular degeneration (AMD) participating at 2 of 28 centers in the Verteporfin in Photodynamic Therapy trial.

Design: Prospective, observational case series.

Participants: Twenty-two eyes of 22 patients with occult with no classic CNV in AMD.

Methods: Patients' reading speed was examined using a German-language reading test (Radner Lesetest). Scotoma size was measured using the microperimetry program 2.01 of the Rodenstock Scanning Laser Ophthalmoscope.

Main Outcome Measures: Reading acuity, reading speed, size of absolute (AS) and relative scotoma (RS).

Results: There was a significant correlation between the size of AS and reading speed ($r = -0.48, P = 0.023$), as well as AS and reading acuity ($r = 0.52, P = 0.013$). No correlation was seen between RS and reading speed or reading capacity.

Conclusion: The size of absolute scotoma correlated significantly with reading capacity and reading speed and may influence these measures.
(VIP) study group as ancillary studies in two centers (Vienna and Lübeck) in the realm of the VIP trial. From both studies, 22 eyes of 22 patients (15 women, 7 men; mean age, 77.6 ± 6.0 standard deviation) with a subfoveal CNV diagnosed by fluorescein angiography were recruited for this baseline examination of the correlation between scotometry and reading speed before randomization in the VIP trial. Principal inclusion criteria for this baseline examination between scotometry and reading speed before randomization included subfoveal occult with no classic CNV lesions in the VIP trial. Principal inclusion criteria for this baseline examination included subfoveal occult with no classic CNV lesions with an approximate Snellen visual acuity at least 20/100 and a lesion size with a greatest linear dimension no greater than 5400 μm. All other patients who were judged by the principal investigator to have classic CNV caused by pathologic myopia and AMD in the VIP trial were excluded. Severe visual impairment caused by other ocular disease was ruled out before recruitment, and all patients’ informed consent was received. All tests were performed before random assignment to the VIP protocol.

Visual acuity was tested using logarithm of the minimum angle of resolution charts following the VIP trial protocol.

Reading Tests

Reading acuity and reading speed were examined in the study eye with a standardized, German-language reading test (Radner Lesetest) using a +4.0 spherical addition for reading. The test methodology has been published elsewhere; patients read short one-sentence texts that had been chosen to be highly comparable in terms of sentence complexity; grammatical difficulty; and number (n = 14), length, and position of words. Two parameters are measured: first, reading acuity defined as log RAD, a word score comparable to the letter score in the Early Treatment of Diabetic Retinopathy Study charts, and second, reading speed defined as words per minute whereby the reading length was determined using a stopwatch. Average reading speed in patients with normal visual acuity is 211.8 ± 34.1 words per minute.

Scotometry

Microperimetry was performed using the scotometry software program (version 2.01) of the scanning laser ophthalmoscope (Rodenstock, Weco Optik Maschinen GmbH D-40231, Düsseldorf, FRG). Stimuli were projected into the center of the fovea with decreased intensity. The first stimulus not recognized was defined as threshold stimulus and was used for delineation of the defect area. Hence, margins were not always well defined for this particular intensity. The size was measured by manual planimetry including all stimuli at the periphery in the measurement. Lack of a standard grid was an advantage, because lesion borders could be tested repeatedly. The following parameters were examined:

1. Definition and planimetry of the size of absolute scotoma (i.e., the area where the patient did not recognize the most-intensive stimuli [in decibels])
2. Definition and planimetry of the size of relative scotoma (i.e., the least-intensive stimuli not recognized by the patients)

Scotoma size was then measured manually based on the planimetry results using the Rodenstock OphthaShare 2.5 software delineating the border at which the stimulus was not seen. All eyes with absolute scotoma had lost central fixation. There was no difference in the center location of large or small scotomas. The configuration was more or less round or oval-round. The diameter in horizontal and vertical direction did not vary significantly.

<table>
<thead>
<tr>
<th>LogMAR</th>
<th>LogRAD</th>
<th>Reading speed (words/min)</th>
<th>Absolute scotoma (mm²)</th>
<th>Relative scotoma (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.396 ± 0.165</td>
<td>0.574 ± 0.293</td>
<td>46.151 ± 16.839</td>
<td>1.299 ± 1.491</td>
<td>8.943 ± 4.965</td>
</tr>
</tbody>
</table>

LogMAR = logarithm of the minimum angle of resolution; logRAD = reading acuity.
Figure 1 illustrates a typical microperimetry result.
Statistical analysis was performed using the Pearson correlation test for bivariate parameters. Statistical significance was set at $P < 0.05$.

**Results**

The size of absolute and relative scotoma was correlated with logRAD and reading speed.

Table 1 summarizes the mean values for the logarithm of the minimum angle of resolution visual acuity, logRAD, reading speed, and the size of absolute and relative scotoma. Absolute scotoma size was $1.299 \pm 1.491$ mm$^2$, and relative scotoma size was $8.943 \pm 4.695$ mm$^2$. The standard deviation is relatively high for all parameters, which highlights the variation in interindividual scotoma size and reading speed.

Table 2 shows the correlation between reading values and scotoma size. LogRAD and absolute scotoma size showed a statistically significant correlation ($P = 0.013$), although the correlation coefficient was not high ($r = 0.523$, Fig 2). There was also a significant correlation between reading speed and absolute scotoma size ($P = 0.023$, $r = -0.484$, Fig 3).

LogRAD and speed did not, however, seem to be influenced by relative scotoma size ($P > 0.05$, Figs 4 and 5). No strong correlation between logRAD and logarithm of the minimum angle of resolution was noted ($P = 0.061$, $r = -0.405$, Fig 6).

**Discussion**

The inability to read or recognize details in everyday tasks in AMD has a substantial effect on patients’ quality of life. In particular, reading speed has a direct influence on patients’ ability to perform everyday tasks independently. Despite the presence of a central scotoma, some patients can handle their disability fairly well if eccentric fixation is established.

Our study shows that the size of absolute scotoma had a
weak correlation with reading speed and logRAD. Other than the small sample size (n = 22), the weakness of the correlation might be the result of the extreme interindividual variability in the sizes of the lesions and of the variation in adapting to eccentric fixation (i.e., some patients can perform better, some worse). Bullimore et al\(^4\) have also reported a similar correlation between reading speed and scotoma size, although scotoma size was not measured using a standardized method. Furthermore, Sunness et al\(^7\) have demonstrated that the size of geographic atrophy directly influences reading rates in atrophic AMD. Therefore, a standardized reading test, like the Radner Reading Charts used for our study, should measure the extent of visual disability very reliably. Furthermore, the same test should also be useful in the assessment of treatment benefit.

Reading tests that measure reading speed and logRAD simultaneously in the same examination can assess patients’ primary problem in AMD more accurately. However, there are very few standardized reading tests available.\(^19\) The Radner reading charts \(^6\) used in this study are, for example, the only German ones. The core of these reading charts is the standardized test sentences that are highly comparable in terms of lexical difficulty, reading length, and construction. These sentences are well suited as test items for logRAD and reading speed determination, because a decrease in reading speed or an increase in reading errors is much more likely to be attributable to the print size than to sentence characteristics. Thus, these charts provide an efficient and quick assessment of patients’ logRAD and speed, which better reflects their everyday needs as seen in other studies.\(^17,20\)

Scotometry provides an efficient method to assess scotoma size in AMD and other diseases \(^9,10,12,22–24\) and central retinal function.\(^14,25–27\) The method is compromised by the high rate of patients’ fixation loss caused by their central scotoma, a disadvantage that can be avoided by real-time fixation control. Therefore, the method elucidates size and depth of scotoma well.\(^27\) All scotomas included the center of the fovea, and depending on the intensity, central fixation was lost or maintained. All absolute scotomas had eccentric fixation, and the exact location of the scotoma was highly variable. The influence of scotoma location on reading rates is controversial.\(^7,8,28,29\) Sunness et al\(^7\) described preferential fixation to the right and above on the retina in patients with geographic atrophy, and Fasce et al\(^8\) have shown preferential fixation in the upper or upper right part of the lesion, although Fletcher et al\(^29\) have seen no influence on reading speed resulting from specific fixation loci.

The size of relative scotoma did not show any correlation with logRAD or speed in our study. Besides the small sample size, the reason for this might lie in the fact that patients grasp words and sentences despite incomplete recognition. Fine et al\(^5\) have shown that sentence context increases reading speed independent of the scotoma position in the retina. McMahon et al\(^30\) have postulated that the sequencing of visual information influences reading speed, which might explain why the relative scotoma does not correlate with reading speed.

One very important issue is the effect of various treatment strategies on logRAD, speed, and scotoma size.\(^11,23,31,32\) The assessment of retinal function is an essential parameter as to whether a therapy is effective.\(^25\) The Macular Photocoagulation Study (MPS) group,\(^33–35\) for example, has reported that reading speed was better in photocoagulated than in untreated eyes.\(^35\) whereby argon-green laser showed slightly better results in comparison to the krypton red laser.\(^33\) Scotometry has shown that central fixation can be preserved after perifoveal laser coagulation that correlated with higher visual acuities than in patients in whom central residual fixation was lost.\(^8\) Scotoma density in these eyes is high, however.\(^34\) In contrast, scotometry before and after surgical extraction of CNV lesions showed less depth of scotoma and slightly better reading compared with laser treatment.\(^34\) Photodynamic therapy with verteporfin has proven to be of benefit in reducing the risk of moderate and severe visual loss compared with a placebo therapy in selected cases of neovascular AMD. Scotometry after this therapy has revealed a restoration of retinal sensitivity with a decrease in central scotoma size \(^36\) and a decreased final size of scotoma in verteporfin-treated patients compared with placebo-treated patients at the 24-month examination (unpublished data; Elsner H, presented at meeting of the Association for Research in Vision and Ophthalmology, Fort Lauderdale, May 2000). Scotometry is a relatively time-consuming procedure for an ophthalmic test and can be performed only with the help of expensive devices. The Radner reading test provides standardized values for the important reading ability of the patient; it is relatively faster and less expensive than scotometry.

In conclusion, this study shows that logRAD and speed were both significantly affected by the size of absolute scotoma in neovascular AMD. The Radner Reading charts seem to be a valuable instrument in the assessment of functional disability and could be used to assess the treatment benefit of new therapeutic procedures in future studies. We have used this test as an ancillary study to the VIP trial examining reading speed and logRAD at baseline, 12, and
24 months in 33 patients. Results of this trial are currently under evaluation.

References