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Contrast sensitivity in retinitis pigmentosa

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SUMMARY Arden gratings were used to measure contrast sensitivity in 40 patients with retinitis pigmentosa whose Snellen visual acuity was 6/12 or better. When compared with a group of 30 normal subjects the patients with retinitis pigmentosa had substantially decreased contrast sensitivity, especially at high frequencies. The Arden grating test appeared to be a sensitive test of abnormal central visual function in patients with retinitis pigmentosa.

The conventional method of determining visual function is by Snellen acuity and visual field testing. However, certain retinal and optic nerve diseases may lead to substantial impairment of visual function, which may not be reflected accurately in tests involving selectively high-contrast figures such as Snellen optotypes. A test of contrast sensitivity at various spatial frequencies may be more sensitive than Snellen acuity in demonstrating visual disturbances. Arden and Jacobson[1 2] have described a simple test to measure contrast sensitivity. Its use has been reported in cases of glaucoma,[1] retrobulbar neuritis,[3] and a variety of macular and optic nerve diseases.[4] We have measured contrast sensitivity in eyes of patients with retinitis pigmentosa with Snellen visual acuity of 6/12 or better. We arbitrarily selected patients with good visual acuity to assess the sensitivity of the Arden grating test in patients who still maintained clinically good foveal function.

Materials and methods

The Arden grating book used has 6 test plates, numbered 2 through 7. Each plate consists of a sinusoidal grating of a single spatial frequency. The gratings subtend 0·2, 0·4, 0·8, 1·6, 3·2, and 6·4 cycles per degree of visual angle, respectively, when viewed at the standard distance of 57 cm. In each plate the contrast of grating bars varies continuously by 0·08 log units per centimeter in a direction parallel to the bars. A scale of 1 to 20 is printed at the side of each plate.

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Patients and normal subjects were tested while wearing their best refractive corrections including a near aid, when appropriate. The plates were held 57 cm from the patient's eye and were illuminated by normal room lights plus a 100-watt desk lamp positioned 35 to 40 cm from the plates. Each eye was tested individually; the right eye was always tested first. All patients were tested by one of 2 examiners (C.R.L. or V.V.).

When using a grating plate the examiners covered all but the lowest contrast portion of the plate with a large card. The tester then withdrew the card slowly, at approximately one division per second, exposing areas of increasing contrast. The patients indicated when they first saw the grating pattern. This point was read off the scale to the nearest half scale unit. This was done twice for each plate and the scores were averaged. If the patient failed to see the grating pattern, a score of 25 was given for the plate. A total score was obtained by calculating the sum of the scores of all the plates. Thirty normal subjects of a similar mean age to the 40 retinitis pigmentosa (RP) patients were tested (Table 1). They had no ocular disease and normal visual acuity.

Of the 40 patients with retinitis pigmentosa tested only those whose eyes had 6/12 vision or better were included in the data analysis (75 of 80 eyes). The patients were categorised by genetic type on criteria previously described.[5] Fifteen patients were autosomal dominant, 12 were autosomal recessive, 4 were X-linked recessive, and 9 were isolated cases (Table 2). All patients with retinitis pigmentosa complained of nyctalopia and showed abnormal rod and cone function by electroretinography. Most underwent

Table 1 *Data for patients and normal subjects*

	No.	Average age, yr	Range
Normal subjects (n=30)			
Female	15	30·2	19–37
Male	15	28·3	25–43
Total	30	29·2	19–43
Patients (n=40)			
Female	19	37·5	22–70
Male	21	35·8	13–69
Total	40	36·6	13–70

Table 2 *Genetic types of retinitis pigmentosa patients*

Genetic type	No.	Average age, yr
Autosomal dominant	15	49·1
Autosomal recessive	12	34·8
X-linked recessive	4	22·5
Isolated	9	41·1
Total	40	36·6

Table 3 *Arden grating results for normal control subjects*

Plate	Mean	SD	Range	Mean + 2 SD
2	12·7	1·57	9·4–15·2	15·9
3	11·0	1·43	7·8–13·9	14·0
4	12·7	1·91	8·5–16·2	16·5
5	11·5	1·85	8·3–14·8	15·2
6	11·8	1·81	8·1–14·4	15·4
7	10·9	1·63	6·2–13·5	14·1
Total	70·5	8·58	50·0–85·5	87·7

Table 4 *Dunnett's test comparisons of mean Arden grating plate scores in controls vs. genetic subgroups of retinitis pigmentosa (RP) patients*

Plate	Controls	RP patients				
		Autosomal dominant	Autosomal recessive	X-linked	Isolated	All RP
	Right eyes (n=30)	(n=14)	(n=11)	(n=4)	(n=8)	(n=37)
2	12·7	14·4*	15·2*	12·6	17·2†	15·0‡
3	11·3	13·3*	12·8	11·5	14·7†	13·3‡
4	13·0	16·7†	13·4	14·4	17·4†	15·6‡
5	11·6	15·4†	13·1	16·4†	16·4†	15·1‡
6	12·1	18·5†	16·5†	19·6†	16·6†	17·6‡
7	11·2	20·7†	19·0†	24·7†	22·2†	21·0‡
Total	72·0	99·0†	89·9†	99·3†	104·5†	97·5‡
	Left eyes (n=30)	(n=14)	(n=11)	(n=4)	(n=9)	(n=38)
2	12·7	15·7†	14·7*	11·8	16·0*	15·1‡
3	10·8	14·4†	13·6*	12·4	15·7†	14·2‡
4	12·3	16·6†	13·7	15·9	16·1†	15·6‡
5	11·4	14·3†	13·1	16·2†	16·2†	14·6‡
6	11·4	15·7†	16·2†	19·6†	17·2†	16·6‡
7	10·6	19·2†	21·4†	24·8†	21·8†	21·1‡
Total	69·3	96·0†	92·6†	100·7†	103·1†	97·2‡

*0·01<p<0·05 for a one-tailed test.
†p<0·01 for a one-tailed test.
‡p<0·005 for a one-tailed *t* test comparing all RP patients with controls.

dark adaptation testing with a Goldmann-Weekers adaptometer; Goldmann perimeter testing was done when possible. Most had variable degrees of pigmentary retinal changes.

Results

There was no significant difference between the results for the right and left eyes of the 30 control subjects (p>0·05). Therefore results of both eyes were averaged together to determine normal values for each plate and for the total of the 6 plates (Table 3). Any value greater than the mean plus 2 standard deviation units was considered to be abnormal. For statistical purposes we compared the findings from right eyes of the control subjects with those of the retinitis pigmentosa patients (Table 4).[6] This was done to decrease the effect of learning or fatigue on the comparisons.

There was a substantial difference between the performance of all retinitis pigmentosa patients compared with the normals for each plate and for the total score. This was also true when patients with just autosomal dominant retinitis pigmentosa or when those patients with isolated disease were considered. Total scores from the autosomal recessive and X-linked patients were also significantly different from those of the normal subjects. However, only the plates that test higher frequencies resulted in substantially poorer scores for the patients in comparison with the normal subjects.

There was a tendency for all patients to do worse than the controls on the high frequency plates (plates 6 and 7). This was emphasised by plotting mean scale readings from the plates versus frequency in cycles per degree of visual angle for normals and all retinitis pigmentosa patients (Fig. 1). The same trend was noted even when results from the 19 retinitis pigmentosa patients with 6/6 vision were considered separately.

The performance of the retinitis pigmentosa patients when grouped by Snellen visual acuity is presented in Table 5. We were interested in whether or not central visual efficiency correlated with the total Arden grating score in our patient group. Visual acuities of 6/6, 6/7·5, 6/9, and 6/12 corresponded to central visual efficiencies of 100, 95, 90, and 85%, respectively.[7] No significant correlation was found (Table 6).

We were also interested in whether or not the field efficiency correlated with the total grating score. We defined percentage field efficiency as the sum of the number of degrees in the 8 principal meridians, using the 4e-II isoptre on the Goldmann apparatus, divided by 5.[8] There was a negative correlation between field efficiency and total grating score, that is, patients with

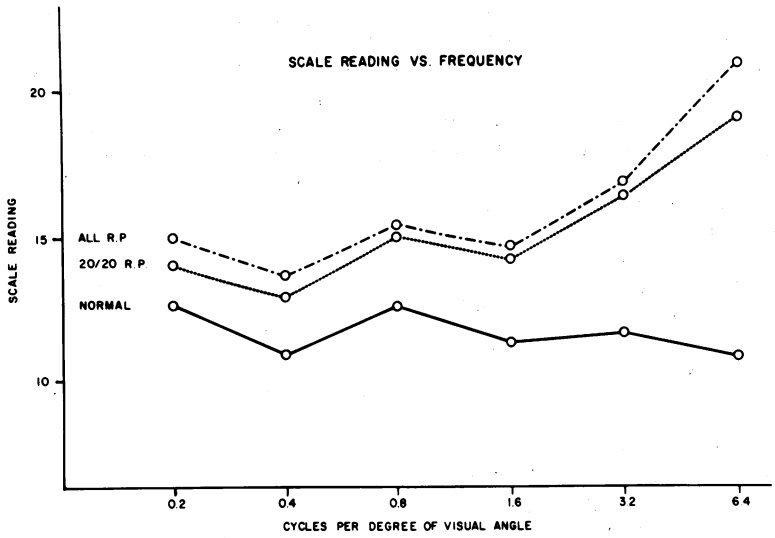

Fig. 1 *A plot of mean plate scale reading versus spatial frequency for normal subjects, all retinitis pigmentosa patients, and retinitis patients with 6/6 vision. Retinitis pigmentosa patients perform more poorly than normal subjects on all frequencies, but especially at high frequencies, even if their Snellen acuity is 6/6.*

lower field efficiencies tended to have higher total grating scores (Table 6).

Discussion

The Arden grating test of contrast sensitivity is an easily administered and sensitive test of visual function. It can demonstrate abnormalities in central visual function that would not be detected by routine Snellen acuity testing. Conversely, in isolated instances patients with poor Snellen acuity can do reasonably well on the Arden gratings. For example, one patient with retinitis pigmentosa not included in this study, with a visual acuity of 6/15−1 OD and 6/18+2 OS, had total Arden grating scores of 79 and 81, respectively, both within the normal range; however, she failed to perceive the gratings entirely on plate 7. Another patient with retinitis pigmentosa had amblyopia due to a right exotropia. The amblyopic eye, not included in the study, had a visual acuity of 6/60 and an Arden grating total score of 90. Although this is an abnormal total grating score, it was less abnormal than some retinitis pigmentosa patients with 6/6 vision. The reasons for these differences are not clear, but certainly good Snellen acuity does not ensure normal contrast sensitivity. We noted that some retinitis pigmentosa patients with poor Snellen acuity who were not included in the study tended to do poorly on the high frequency plates, although the results of the low frequency plates and total score still fell within the normal range (mean±2 SD). The high frequency plates test foveal function more exclusively than the Snellen test.

Table 5 *Dunnett's test comparisons of mean Arden grating plate scores for controls vs. retinitis pigmentosa (RP) patients by visual acuity*

Plate	*Controls*	*RP patients*			
		6/6	*6/7·5*	*6/9*	*6/12*
	Right eyes				
	(n=30)	*(n=7)*	*(n=12)*	*(n=9)*	*(n=9)*
2	12·7	13·7	15·7†	14·6	15·5*
3	11·3	12·7	13·6*	12·5	14·0*
4	13·0	14·6	15·5*	16·2*	16·0*
5	11·6	13·5	15·1†	15·2†	16·1†
6	12·1	16·3†	17·8†	16·3†	19·7†
7	11·2	19·7†	21·0†	21·4†	21·6‡
Total	72·0	90·5†	98·6†	96·2†	102·9†
	Left eyes				
	(n=30)	*(n=12)*	*(n=7)*	*(n=6)*	*(n=13)*
2	12·7	14·4	15·9*	12·8	16·3†
3	10·8	13·3†	14·8†	12·6	15·6†
4	12·3	15·2	15·2	13·3	17·2†
5	11·4	14·6	12·6	13·9	16·1
6	11·4	16·3†	12·9	18·1†	18·2†
7	10·6	18·6†	20·6†	25·0†	21·8†
Total	69·3	92·4†	92·1†	95·7†	105·2†

*0·01<p<0·05 for a one-tailed test.
†p<0·01 for a one-tailed test.

Table 6 *Correlation of field efficiency and central efficiency with mean Arden grating total plate scores*

Comparison	*n*	*r*	*p*
Right eye			
Field efficiency	34	−0·32	0·07
Central efficiency	37	−0·19	0·26
Left eye			
Field efficiency	36	−0·34	0·04
Central efficiency	38	−0·27	0·09

When considering only patients with 6/12 acuity or better, we could not demonstrate a positive correlation between visual acuity and Arden grating total score. Perhaps this is because our patients had a relatively narrow visual acuity range (6/6 to 6/12). However, there did seem to be a relationship between total grating score and field efficiency. Higher total grating scores (poorer performance) correlated with lower field efficiencies. The perception of a lower frequency grating must depend on the integrity of a larger area of retina. Thus it is understandable that low frequency grating scores would be poor if field efficiency is reduced, despite normal Snellen acuity. However, the reason why high frequency grating scores are also poor is uncertain.

Contrast sensitivity testing has some disadvantages. First, it lacks specificity, in that abnormal scores are obtained in many disease processes, for example, glaucoma, optic neuritis, cone-rod dystrophies, senile macular degeneration, cystoid macular oedema, ischaemic optic neuropathy, diabetes, and amblyopia.[1–4] Age also affects performance.[4,9] Secondly, there are potential problems with reproducibility in Arden grating testing. For example, test distance, lighting, and speed at which the gratings are uncovered need to be carefully controlled. Finally, the test is subjective. There is no right or wrong response, as in Snellen acuity testing. Some patients who are anxious to please the examiner may claim to discern the gratings before they are actually apparent. Others may delay indicating that they see the gratings because they want to be absolutely sure.

Despite its disadvantages the Arden grating test was shown to be useful in detecting abnormal visual function in retinitis pigmentosa patients with normal or near normal Snellen acuity.

Why patients with autosomal recessive and X-linked recessive diseases in this study showed better performance on the lower frequency plates than isolated and autosomal dominant patients is uncertain. The test has promise as a sensitive means for following central cone function in retinitis pigmentosa patients with clinically mild foveal disease.

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