

# CONTRAST SENSITIVITY IN DIABETIC RETINOPATHY

VLAD RUSU<sup>1</sup>, ELENA MIHAÏ<sup>2</sup>, ADRIANA STĂNILĂ<sup>3</sup>

<sup>1,2</sup>Clinical County Emergency Hospital Sibiu, <sup>3</sup>“Lucian Blaga” University of Sibiu

**Keywords:** contrast sensitivity, diabetic retinopathy, laser photocoagulation

**Abstract:** Contrast sensitivity is one of the components of visual function, which is affected even in early subclinical stages of various eye diseases, including diabetic retinopathy. We present theoretical and practical aspects related to the evolution of contrast sensitivity before and after laser photocoagulation in diabetic retinopathy.

**Cuvinte cheie:** sensibilitate la contrast, retinopatie diabetică, fotocoagulare laser

**Rezumat:** Sensibilitatea la contrast reprezintă una din componentele funcției vizuale, fiind afectată încă din stadii subclinice ale diferitelor afecțiuni oftalmologice, printre care și retinopatia diabetică. Se prezintă aspecte teoretice și practice legate de evoluția sensibilității la contrast, înainte și după fotocoagularea laser în retinopatia diabetică.

## INTRODUCTION

Contrast sensitivity (CS) is defined as the ability to distinguish details at low contrast levels. CS expresses visual analyzer's ability to perceive differences in brightness between adjacent fields. Visual system's ability to realize the difference between objects and background at the level of finest details can be expressed as the maximum level of contrast sensitivity. Used for decades, contrast sensitivity testing was commonly used in experiments and clinical trials. Use of it as routine examination had relatively limited application. Lately it has been reconsidered the importance of contrast sensitivity in assessing visual performance. Its usefulness as a method for examining visual function was demonstrated in situations where impaired visual function is not expressed by changes in usual indicators: visual acuity or visual field.

Contrast is created by the difference between reflected light - luminance - of two adjacent surfaces, rendered by Michaelson's equation:

$$\text{CONTRAST} = \frac{\text{Luminance of bright surface} - \text{Luminance of dark surface}}{\text{Luminance of bright surface} + \text{Luminance of dark surface}}$$

CONTRAST =

$$\frac{\text{Luminance of bright surface} - \text{Luminance of dark surface}}{\text{Luminance of bright surface} + \text{Luminance of dark surface}}$$

The contrast is usually expressed as a percentage, the fraction being multiplied by 100. If the lowest perceived contrast is 5% contrast sensitivity is  $100/5 = 20$ . If the lowest perceived contrast of a person is 0.6% contrast sensitivity is  $SC = 100/0.6 = 170$  (figure no. 1). If a person is able to distinguish details in low contrast, sensitivity to contrast is high and vice versa.

Figure no. 1. Levels of contrast

100%	25%	10%	5%	2.5%	1.25%	0.6%
------	-----	-----	----	------	-------	------

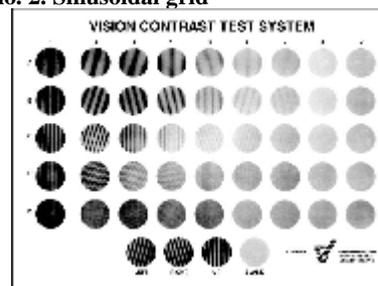
Contrast sensitivity testing can be done using systems of letters, figures or grids that are in the form of boards or video monitors. Testing can be done under photopic, mesopic and scotopic conditions associated with glare sensitivity tests.

Sinusoidal grids are presented as black and white alternate lines whose intensity varies sinusoidally, the visual system decoding the scenes in sinuous language (figure no. 2).

Determination of contrast sensitivity consists in

testing these sinusoidal networks - the only real stimuli perceived by the brain. The retina acts like a microcomputer that decomposes the projected images into a sum of sinusoidal networks with variable contrast.

Figure no. 2. Sinusoidal grid



The most widely used letter systems are Pelli-Robson (figure no. 3) and Regan tests.

Figure no. 3. Pelli-Robson test



Pelli-Robson test advantages:

- is easily understood by patients
- no special examination conditions required

<sup>1</sup>Corresponding author: Vlad Rusu, Str. Ion Creangă, Nr. 8, Șelimbăr, România, E-mail: vladr@yahoo.com, Tel: +40744 621200  
Article received on 04.04.2014 and accepted for publication on 25.08.2014  
ACTA MEDICA TRANSILVANICA September 2014;2(3):193-195

## CLINICAL ASPECTS

- is carried out quickly (up to 8 min.)
- is quickly and easily to interpret, requiring no graphic representation
- relatively low price
- Disadvantages:
  - explore the low frequency of contrast

Regan Low Contrast presents three boards, with decreasing size of the letter, the lowest being equivalent to 6/3 Snellen VA, contrast decreases 96%, 7%, 4%. The test is not affected by refraction, is mostly used to assess the progression of cataracts (figure no. 4).

**Figure no. 4. Regan Low Contrast test**



### CASE REPORT

N.M., a 67-year old female presents with decreased visual acuity.

Past medical history:

- Type 2 diabetes mellitus treated with insulin
- Diabetic retinopathy

Ophthalmologic exam:

- BCVA RE=0.5; LE=0.5
- IOP RE=17mmHg; LE=16mmHg
- CSRE=1,35uLog; CSLE=1,20uLog; CSBE=1,45uLog
- Anterior segment: normal
- Fundus examination: hemorrhages and few hard exudates disseminated throughout, neovascularisation at disc, mild fibrovascular proliferation LE>RE (figures no. 5,6).

**Figure no. 5. RE fundus image**



**Figure no. 6. LE fundus image**



To examine contrast sensitivity we used Pelli-Robson test with associated CS chart (figure no. 7).

**Figure no. 7. Pelli-Robson contrast sensitivity chart**

**PELLI-ROBSON CONTRAST SENSITIVITY TEST**

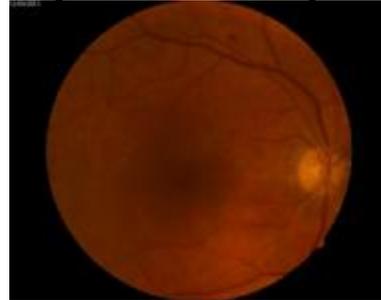
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0.15</td><td>V R S</td><td>K O R</td><td>0.15</td></tr> <tr><td>0.30</td><td>N H C</td><td>R O K</td><td>0.45</td></tr> <tr><td>0.60</td><td>S C N</td><td>O Z V</td><td>0.75</td></tr> <tr><td>0.90</td><td>C N H</td><td>Z O K</td><td>1.05</td></tr> <tr><td>1.20</td><td>N O D</td><td>V H R</td><td>1.35</td></tr> <tr><td>1.50</td><td>C D N</td><td>Z B V</td><td>1.65</td></tr> <tr><td>1.80</td><td>K O H</td><td>O O K</td><td>1.95</td></tr> <tr><td>2.10</td><td>R S Z</td><td>H V R</td><td>2.25</td></tr> </table>	0.15	V R S	K O R	0.15	0.30	N H C	R O K	0.45	0.60	S C N	O Z V	0.75	0.90	C N H	Z O K	1.05	1.20	N O D	V H R	1.35	1.50	C D N	Z B V	1.65	1.80	K O H	O O K	1.95	2.10	R S Z	H V R	2.25	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0.30</td><td>V R R</td><td>K O R</td><td>0.35</td></tr> <tr><td>0.30</td><td>N H C</td><td>R O K</td><td>0.45</td></tr> <tr><td>0.60</td><td>S C N</td><td>O Z V</td><td>0.75</td></tr> <tr><td>0.90</td><td>C N H</td><td>Z O K</td><td>1.05</td></tr> <tr><td>1.20</td><td>N O D</td><td>V H R</td><td>1.35</td></tr> <tr><td>1.50</td><td>C D N</td><td>Z B V</td><td>1.65</td></tr> <tr><td>1.80</td><td>K O H</td><td>O O K</td><td>1.95</td></tr> <tr><td>2.10</td><td>R S Z</td><td>H V R</td><td>2.25</td></tr> </table>	0.30	V R R	K O R	0.35	0.30	N H C	R O K	0.45	0.60	S C N	O Z V	0.75	0.90	C N H	Z O K	1.05	1.20	N O D	V H R	1.35	1.50	C D N	Z B V	1.65	1.80	K O H	O O K	1.95	2.10	R S Z	H V R	2.25	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0.30</td><td>V R R</td><td>K O R</td><td>0.35</td></tr> <tr><td>0.30</td><td>N H C</td><td>R O K</td><td>0.45</td></tr> <tr><td>0.60</td><td>S C N</td><td>O Z V</td><td>0.75</td></tr> <tr><td>0.90</td><td>C N H</td><td>Z O K</td><td>1.05</td></tr> <tr><td>1.20</td><td>N O D</td><td>V H R</td><td>1.35</td></tr> <tr><td>1.50</td><td>C D N</td><td>Z B V</td><td>1.65</td></tr> <tr><td>1.80</td><td>K O H</td><td>O O K</td><td>1.95</td></tr> <tr><td>2.10</td><td>R S Z</td><td>H V R</td><td>2.25</td></tr> </table>	0.30	V R R	K O R	0.35	0.30	N H C	R O K	0.45	0.60	S C N	O Z V	0.75	0.90	C N H	Z O K	1.05	1.20	N O D	V H R	1.35	1.50	C D N	Z B V	1.65	1.80	K O H	O O K	1.95	2.10	R S Z	H V R	2.25
0.15	V R S	K O R	0.15																																																																																															
0.30	N H C	R O K	0.45																																																																																															
0.60	S C N	O Z V	0.75																																																																																															
0.90	C N H	Z O K	1.05																																																																																															
1.20	N O D	V H R	1.35																																																																																															
1.50	C D N	Z B V	1.65																																																																																															
1.80	K O H	O O K	1.95																																																																																															
2.10	R S Z	H V R	2.25																																																																																															
0.30	V R R	K O R	0.35																																																																																															
0.30	N H C	R O K	0.45																																																																																															
0.60	S C N	O Z V	0.75																																																																																															
0.90	C N H	Z O K	1.05																																																																																															
1.20	N O D	V H R	1.35																																																																																															
1.50	C D N	Z B V	1.65																																																																																															
1.80	K O H	O O K	1.95																																																																																															
2.10	R S Z	H V R	2.25																																																																																															
0.30	V R R	K O R	0.35																																																																																															
0.30	N H C	R O K	0.45																																																																																															
0.60	S C N	O Z V	0.75																																																																																															
0.90	C N H	Z O K	1.05																																																																																															
1.20	N O D	V H R	1.35																																																																																															
1.50	C D N	Z B V	1.65																																																																																															
1.80	K O H	O O K	1.95																																																																																															
2.10	R S Z	H V R	2.25																																																																																															
Right Eye	Bimocular	Left Eye																																																																																																
Log Contrast Sensitivity: _____	Log Contrast Sensitivity: _____	Log Contrast Sensitivity: _____																																																																																																
Acuity: _____	Acuity: _____	Acuity: _____																																																																																																
Comments: _____	Comments: _____	Comments: _____																																																																																																
Pupil Diameter: _____ mm		Pupil Diameter: _____ mm																																																																																																
Name: _____	Comments: _____																																																																																																	
Age: _____																																																																																																		
Diagnosis: _____																																																																																																		
Medication: _____																																																																																																		
Date: _____																																																																																																		
Examiner: _____																																																																																																		

Because the patient had a moderate stage of proliferative diabetic retinopathy, we decided to initiate laser photocoagulation treatment. Focal laser photocoagulation in the macular region areas of interest was performed first, then laser panphotocoagulation divided into four sessions.

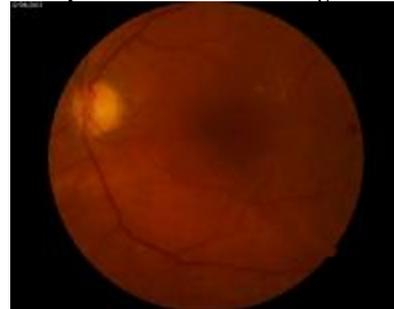
Three months post laser treatment check:

- BCVA RE=0,6; LE=0,6
- IOP RE=18mmHg; LE=17mmHg
- CSRE=1,35uLog; CSLE=1,35uLog; CSBE=1,50uLog
- Fundus exam: regression of hemorrhages, disappearance of neovascularization (figures no. 8,9).

**Figure no.8. RE post laser treatment image**



**Figure no. 9. LE post laser treatment image**



Diabetic retinopathy affects all components of visual function. Visual acuity is variably altered by macular damage, decreasing progressively as macular edema worsens. Visual field shows relative or absolute scotomas corresponding to non perfused areas. Colour vision is disrupted since early stages, blue-yellow axis dyschromatopsia is due to the selective depression of the sensitivity of cones that perceive blue colour. Contrast sensitivity is also affected early, even if visual acuity remains good and there is no ophthalmoscopic evidence of changes in the retina. The mechanism of loss of contrast sensitivity is still not known well although hyperglycemia-related changes of the retina, which result in accumulation of abnormal fluid, have been suggested. Some studies showed that

## CLINICAL ASPECTS

---

loss of contrast sensitivity correlates with enlargement of the foveal avascular zone.

Contrast sensitivity is the first of visual functions affected and the last to return to normal in neuro-ophthalmologic disorders. It is an important aspect of visual function and is even more important for ordinary daily tasks than visual acuity. In our case there was an improvement of contrast sensitivity after laser photocoagulation correlated with a decrease in central retinal thickness (reduced macular edema).

### REFERENCES

1. Farahvash MS, Mahmoudi AH, Farahvash MM, Tabatabaee A, Riazi M, Mohammadzadeh S, Faghihi H, Nilli-Ahmadabadi M, Mirshahi A, Karkhaneh R, Aalami-Harandi, Z Javadian A, Abdolahi A, Lashey A. The Impact of Macular Laser Photocoagulation on Contrast Sensitivity Function in Patients with Clinically Significant Macular Edema, *Archives of Iranian Medicine* 2008;11(2):143-147.
2. Arden GB. Testing contrast sensitivity in clinical practice. *Clin Vis Sci* 1998. p. 2-213.
3. Murray IJ, Plainis S. Contrast coding and magno/parvo segregation revealed in reaction time studies, *Vision research* 2003;43(25):2707-2719.
4. Byron L. Diagnostic Examination and Testing in Ophthalmology, Section I, Cap. 1- The Ophthalmic Examination - Atlas of Ophthalmology CD ROM, Ed. Parrish II Richard; 2000.
5. Mihai E. Sensibilitatea la contrast în diagnosticul suferințelor ischemice și a unor suferințe toxice ale nervului optic; 2008.
6. Cernea P. *Tratat de oftalmologie*, ediția a 2-a, Ed. Medicală, București; 2002.
7. Kanski JJ. *Clinical Ophthalmology*, fourth edition, Butterworth-Heinemann, Edinburgh; 2002.
8. Talgar CP, Pelli D, Carrasco M. Covert attention enhances letter identification without affecting channel tuning. *Journal of Vision* 2004;4(1):22-31.
9. Buiuc S. *Principii Teoretice si Practice de Oftalmologie*, vol.I, editura Tehnopress Iasi; 2000. p. 97-102.

Diabetic retinopathy is an eye disease caused by the high blood sugar from diabetes. It damages blood vessels in the retina and can make abnormal new blood vessels. You can have diabetic retinopathy and not know it. This is because it often has no symptoms in its early stages. As diabetic retinopathy gets worse, you will notice symptoms such as blurred vision, floaters, and dark spots. Diabetic Retinopathy is a complication of type 2 diabetes. According to the IAPB (International Agency for the Prevention of Blindness) [1] report published in 2017, there were 422 million people diagnosed with diabetes. 1 in 3 people diagnosed with diabetes will have diabetic retinopathy up to a certain degree and 1 in 10 people will suffer from vision loss. DR results in the damage of blood vessels in the retinal layer of the eye. This image processing technique improves the contrast of the image. It is usually performed on small regions of the image called tiles. This helps in enhancing the edges of the image. Contrast sensitivity was significantly lower in diabetic eyes with retinopathy than in the normal eyes ( $p = 0.011$ ) or the diabetic eyes without retinopathy ( $p = 0.033$ ). They opine that the test may be of value in screening diabetic patients for retinopathy in primary care facilities. (2). In another study also similar results were seen. The results showed an obvious decrease in contrast sensitivity in diabetic retinopathy. Even patients without retinopathy showed reduced contrast sensitivity when compared to controls. Also there was a definite relation between contrast sense and glycemic control. (4). Dosso AA et al evaluated contrast sensitivity in insulin resistant obese individuals and in aretinopathic diabetic patients and found that it was low. To evaluate contrast sensitivity in patients with diabetic retinopathy (DR) treated with argon laser panphotocoagulation. Prospective study of patients with diabetic retinopathy and 20/20 visual acuity, treated with retinal panphotocoagulation, following ETDRS criteria. The patients were submitted, initially, to complete ophthalmologic evaluation and contrast sensitivity testing (Vision Contrast Test System).