

Effect of retinal laser photocoagulation on contrast sensitivity and visual acuity in patients of diabetic retinopathy

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Abstract- Objective: To measure the effect of retinal laser on contrast sensitivity (CS), visual acuity and self reported visual disability in patients of diabetic retinopathy (DR).

Methods: A prospective and analytical study in 53 eyes undergoing frequency doubled Nd-YAG retinal laser photocoagulation for DR was conducted over a period of 1 year at a tertiary care center. Best corrected visual acuity (BCVA) and CS were measured before each laser sitting and on subsequent follow-ups. The pre-laser measurements were compared with those of 3 month follow-up. On the final visit a self reported visual disability questionnaire was administered.

Results: The mean improvement in BCVA and CS was 0.07 logMAR and 0.11 logCS units respectively. Improvement in CS is maximum following focal laser. A statistically significant difference is found between the pre and post laser BCVA ($P = 0.014$) and CS ($P = 0.001$). A good statistical correlation is established between CS and self reported visual disability (correlation coefficient = 0.75) while the latter has a weaker correlation with BCVA.

Conclusions: Laser photocoagulation has a definitive role in stabilizing visual function in patients with DR. CS is better correlated with self reported visual disability and thus measures functional visual improvement better than the conventional high-contrast visual acuity.

Index Terms- Contrast sensitivity, diabetic retinopathy, diabetic macular edema, laser photocoagulation,

I. INTRODUCTION

The prevalence of adult diabetes worldwide is anticipated to rise from 4.0% in 1995 to 5.4% by 2025.¹ Given this rising prevalence, it is expected that diabetic retinopathy and diabetic macular edema (DME) will continue to be common and will be important causes of visual impairment. As per the World Health Organisation (WHO) estimates, India has 31.7 million diabetic subjects.² The prevalence of diabetic retinopathy (DR) in type-2 DM was found to be 35-39% in the United Kingdom Prospective Diabetes Study (UKPDS).³ DR is the leading cause of legal and functional blindness for people in their working years.⁴

Visual acuity has been used conventionally as the sole measure of visual function in patients coming to the eye clinic for various ocular conditions. The most commonly used Snellen's vision chart for distant vision, uses a high contrast of black letters in

white illuminated background for measurement of visual acuity. This high contrast is not present in our day to day life and surroundings and thus patients giving a good visual acuity on Snellen's chart may not actually be experiencing the same visual sharpness and clarity in their routine life.

A study of health related quality of life (HRQoL) appraises contrast sensitivity (CS) as a newer measure of visual function and its value in determining HRQoL and health utility in comparison to the most standard measure, visual acuity. It shows that CS has significant and independent properties to visual acuity.⁵ Visual function at low contrast is an essential part of visual capability which may change independently of visual function at high contrast and thus both the areas of function should be investigated. Neither visual acuity nor CS losses are specific findings; they rather depict loss of certain kind of visual information somewhere in its long optical and neural processing path.⁶

Patients undergoing argon laser panretinal photocoagulation (PRP) for proliferative diabetic retinopathy (PDR) developed temporary losses in high spatial frequency CS during the closely spaced PRP treatments. Since Snellen's visual acuity remained stable at the pre-laser level, these results indicate the need for more sensitive measures of visual resolution to monitor foveal integrity in patients undergoing PRP.⁷ Hellstedt et al.⁸ suggested that contrast sensitivity is a sensitive indicator of changes in diabetic retinopathy and macular edema, especially at low- to mid- range spatial frequencies. Isolated losses of CS exist in certain diseases, and in many others, loss of contrast sensitivity is more prominent and disturbing to the patient than the loss of visual acuity.⁹

Contrast acuity tests may provide clinically relevant information about the functional visual performance and may be included in the clinical evaluation of patients when we want to evaluate functionally relevant visual impairment in the absence of high-contrast visual acuity loss. Vision under reduced light or contrast conditions should be considered for estimating real-life visual performance.¹⁰ Keeping in mind the importance of CS in day to day activities, this study has been conducted to measure the change in CS and visual acuity after retinal laser in DR patients.

II. MATERIALS AND METHODS

A prospective and analytical study was conducted over a period of one year at the ophthalmology out patient department of a tertiary care center. Thirty three patients with various stages of diabetic retinopathy undergoing frequency doubled NdYag retinal laser photocoagulation and fitting into the eligibility criteria were consecutively recruited out of which three patients were excluded from statistical analysis due to lack of follow up. The exclusion criteria consisted of best corrected visual acuity (BCVA) less than 3/60, patients with ocular co-morbidities like retinal disorders (except diabetic retinopathy), optic nerve diseases, corneal dystrophies and those who have previously received retinal laser.

BCVA and CS were taken before laser photocoagulation (pre-dilatation). On the consecutive follow up BCVA and CS were measured and recorded till 3 months after the first laser sitting.

Visual acuity was assessed by self-illuminated Snellen acuity charts placed at a distance of 6 m (20 ft) from the patient with an illumination of 100 lux. Pinhole vision was taken and BCVA taken after giving appropriate spherical and cylindrical correction. Snellen's BCVA measurements were converted into logMAR units for statistical analysis using the table originally given by Ferris et al.¹¹

The Pelli-Robson Chart (Clement Clarke International Ltd.; Columbus, OH.) was used to measure CS which is a wall chart displaying letters of constant size with 16 letter triplets. Three letters form a triplet of equal contrast and contrast decreases from row to row by a factor of 2 (i.e., 0.15 logCS units per triplet). The test chart was illuminated by room light providing a background luminance of 100 cd/m² (minimum 91 cd/m²; maximum 102 cd/m²). Testing was carried out at 1 m (LogMAR equivalent 1.3) before dilating the pupils with the patient wearing his best spectacle correction.¹² Testing was carried out by a single trained observer.

A detailed ocular examination was carried out prior to laser photocoagulation. Direct, indirect ophthalmoscopy and slit lamp biomicroscopy of posterior segment using a 90D (Volk Optical Inc.) lens were carried out. A thorough slit lamp evaluation of anterior segment and central corneal thickness corrected goldman applanation tonometry (GAT) was performed ruling out other existing ocular co-morbidities. Fundus fluorescein angiography (FFA) was performed to access macular ischemia, macular edema, capillary non-perfusion areas and neovascularisation prior to laser photocoagulation. The procedure was carried out by adhering to the protocols and with emergency resuscitation drugs.

A written and informed consent was taken prior to laser photocoagulation which was performed by a single vitreo-retinal surgeon. Panretinal photocoagulation (PRP) was done for patients with PDR (proliferative diabetic retinopathy) or severe NPDR (non-proliferative diabetic retinopathy). The number of sittings of PRP were decided in terms of the amount of regression of neovascular disease and achievement of fibrous avascular tissue. In focal photocoagulation light, small-sized

burns to leaking microaneurysms in the macula outside the foveal avascular zone were given.

Three months after the last laser session participants were administered a structured questionnaire in the vernacular language regarding their visual disabilities before and after laser treatment. The questionnaire was administered by a single trained interviewer who was blind folded regarding the BCVA and CS of the participants. Questions mentioned in the questionnaire were adapted from NEI VFQ-25 (National Eye Institute, Visual Function Questionnaire (25 Item)) and VDQ (visual disability questionnaire). VFQ-25 was selected because of the scale being able to compare the relative burden of visual disorders on the same scale which is designed to capture the impact of visual problems on physical functioning, emotional wellbeing and social functioning. The rigorous multi-condition evaluation of the scale proved it to be reliable and valid.¹³ VDQ has been designed in India by Marella et al.¹⁴ keeping in mind the Indian population and the difficulties they face in their daily activities. Activities like self grooming which was given maximum importance by the participants with visual disabilities have been incorporated in our questionnaire. The response from participants was recorded as worsening, improvement or no change as compared to the discomfort in these activities prior to laser treatment.

III. RESULTS

Out of a total of 53 eyes (30 participants), 20 were males and 10 were females. The age of patients ranged from 43 to 75 years. Following is the age-wise distribution of DR. (Table 1)

Table 1: Age-wise distribution of diabetic retinopathy

Age group (Years)	Percent % n=53	NPDR without CSME % n=2	NPDR with CSME % n=30	PDR without CSME % n=6	PDR with CSME/MI*/HRC† % n=15
41-50	15.1	12.5	25.0	25.0	37.5
51-60	41.5	0.0	68.2	4.5	27.3
61-70	37.7	0.0	55.0	15.0	30.0
71-80	5.7	33.3	66.7	0.0	0.0
Total	100.0	3.8	56.6	11.3	28.3

* Macular ischemia

† High risk characteristics

Out of 53 eyes, 41.5% received focal laser, 30.2% received focal laser followed by PRP while the remaining eyes received PRP.

Overall, the mean pre-treatment BCVA (Best corrected visual acuity) was 0.42 logMAR units and that on an average after 3 months of laser photocoagulation was 0.35 logMAR units. This shows a net improvement of 0.07 logMAR units. The mean pre-treatment CS was 1.86 logCS units and that after 3 months of

laser photocoagulation was 1.97 logCS units. This shows a net improvement in the CS of 0.11 logCS units.

There is an improvement in mean BCVA with all the three types of laser used in the study. The mean improvement in CS is maximum in patients who had taken focal laser that is 0.14 units. Table shows the mean change in BCVA and CS following laser. (Table 2)

Table 2: Mean change in BCVA and CS according to the type of laser photocoagulation

Type of Laser	Frequency	Mean Change in BCVA	Mean Change in CS
PRP	15	-0.033	0.040
Focal laser	22	-0.079	0.143
Focal laser followed by PRP	16	-0.096	0.131
Total	53	-0.071	0.110

Overall, a statistically significant difference is found between the pre and post laser BCVA ($p=0.014$) and CS ($p=0.001$). This difference in CS is the maximum in patients undergoing focal laser photocoagulation for CSME ($p=0.004$). Results of t-test for pre laser and post laser BCVA and CS is shown. (Table 3)

Table 3: Results of paired t-test for pre laser and post laser BCVA and CS

Pair	Mean difference after laser	Std. Deviation	95% confidence interval		P value
Pre and post laser BCVA	-0.071	0.203	-0.127	-0.015	0.014
Pre and post laser CS	0.110	0.232	0.046	0.174	0.001

Table 4: Change in CS, BCVA and self reported visual acuity according to type of laser given and type of DR

Change in parameters compared to baseline		Status of Diabetic Retinopathy				Type of Laser		
		NPDR without CSME % n=2	NPDR with CSME % n=30	PDR without CSME % n=6	PDR with CSME/ MI*/HRC† % n=15	PRP % n=15	Focal laser % n=22	Focal laser followed by PRP % n=16
Contrast Sensitivity	<i>No change</i>	0	33.3	66.7	40	53.3	18.2	50
	<i>Worsening</i>	50	13.3	0	13.3	20	9.1	12.5
	<i>Improvement</i>	50	53.3	33.3	46.7	26.7	72.7	37.5
Best Corrected Visual Acuity	<i>No change</i>	0.0	36.7	50.0	46.7	40.0	36.4	43.8
	<i>Improvement</i>	50.0	36.7	16.7	46.7	26.7	40.9	43.8
	<i>Worsening</i>	50.0	26.7	33.3	6.7	33.3	22.7	12.5
Self Reported Visual Disability	<i>No change</i>	50.0	60.0	83.3	53.3	73.3	40.9	75.0
	<i>Worsening</i>	0.0	6.7	0.0	0.0	0.0	9.1	0.0
	<i>Improvement</i>	50.0	33.3	16.7	46.7	26.7	50.0	25.0

* Macular ischemia

† High risk characteristics

Chart shows the change in BCVA and CS from baseline on the final follow up (3 months) after laser photocoagulation. (Chart

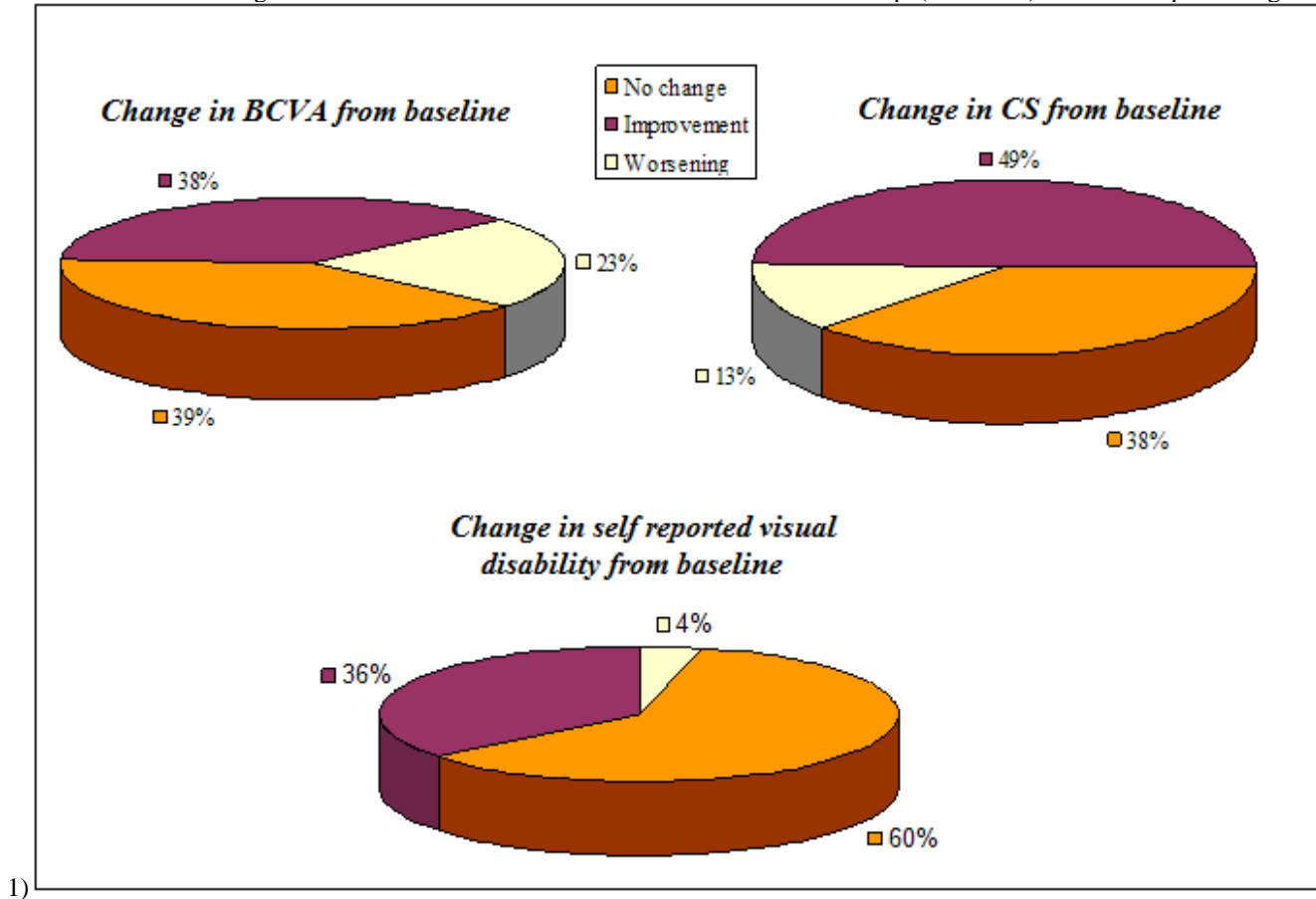


Chart 1: Change in BCVA and CS from baseline on the final follow up (3 months) after laser photocoagulation.

IV. DISCUSSION

In the study we found that around 38% of the eyes treated with laser photocoagulation had an improvement in BCVA compared to the baseline, while 40% maintained a stable vision. Remaining 23% had a drop in the post laser BCVA in the final follow up. CS improved from the baseline in 49.1% (26 eyes) of the eyes out of which 61.5% (16 eyes) had undergone focal laser for DME. A decrease in CS compared to baseline was observed in 20% of the eyes undergoing PRP which is more as compared to that with focal laser (9%). Lövestam-Adrian et al.¹⁵ in their study in 20 eyes treated with PRP for proliferative diabetic retinopathy too noted a loss in CS following PRP compared to the untreated eyes. Despite of the fact that focal laser has its maximum effect on the cones at macula, CS improves the most after focal laser due to the resolution of macular edema following treatment.

Olk in a randomized clinical trial involving 92 patients with diffuse diabetic maculopathy, reported an improvement in the BCVA in 45% of the eyes and a stable vision in another 45% of eyes, showing a positive effect of laser photocoagulation in patients with DME.¹⁶

A questionnaire for self reported visual disability was administered to the participants 3 months after laser photocoagulation. The questionnaire consisted of activities of daily living like recognizing faces, picking out things from crowded shelf, self grooming and doing activities in dim light. The response was recorded as worsening, improvement or no change as compared to the discomfort in these activities prior to laser treatment. Here too, an improvement of visual function was noted in 50% of the eyes undergoing focal laser. Overall, 60% of the participants experienced no change in their daily visual activities while 36% had an improvement in the same. This clearly depicts that laser photocoagulation has a definitive role in stabilizing subjective visual function.

Aiello et al. in a multicenter randomized clinical trial studied the factors associated with the visual acuity outcome after focal/grid photocoagulation for DME in 393 eyes found that worse baseline visual acuity was only associated with frequent visual acuity improvement. They concluded that focal/grid laser photocoagulation remains the standard management for DME. Visual acuity improved from baseline in 32% of eyes and worsened in 19% of eyes.¹⁷ It has previously been shown by Striph et al. that diabetic macular oedema produces a

generalized loss of threshold sensitivity across the central 10° of the visual field following modified grid treatment.¹⁸

Despite of the advent of anti-VEGFs in treatment of DR, laser photocoagulation still plays a vital role in management of DR and will continue to be a pivotal component for the next several years.¹⁹ In the multicentre randomized clinical trial by the DRCR network it had been shown that over a two year period, focal/grid photocoagulation was more effective and had fewer side effects than 1-mg or 4-mg doses of preservative-free intravitreal triamcinolone for most patients with DME. The study supported the fact of focal/grid laser photocoagulation being effective in the treatment of DME.²⁰ The results of the RESTORE study by Mitchell et al.²¹ advocate a combined modality of treatment for DME in the form of ranibizumab with laser photocoagulation. Excellent to good eyesight was reported by 50% of the patients who had taken a combined treatment (determined by the individual NEI VFQ-25 question pertaining to patient's perception of eyesight post-treatment). The present study shows that laser photocoagulation has a distinct role in maintaining a stable visual acuity in patients with DR. Improvement in CS is the maximum after focal laser in CSME due to the subsidence of macular edema. Majority of the patients demonstrate no change in the self reported visual disability after laser treatment (60.4%) while only a few patients experienced a worsening (3.8%).

CS is thus a very useful tool in conjunction with visual acuity in patients with DR as it correlates with the subjective visual disability better than high contrast visual acuity in Snellen's charts. We thus recommend measurement of CS in all patients of DR. The laser parameters used for retinal laser like power, duration and number of shots are individualised from patient to patient depending on the type of DR. These parameters thus cannot be accurately compared or correlated with the change in visual function. Further studies with much larger sample size need to be conducted to quantify the laser parameters that are associated with a change in visual function.

V. CONCLUSION

Laser photocoagulation has a definitive role in stabilizing visual function in patients with DR. CS is better correlated with self reported visual disability and thus measures functional visual improvement better than the conventional high-contrast visual acuity.

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