Subject Area:

Effect of pattern-diode laser on central macular thickness and ganglion-cell complex after application in management of clinically significant macular edema

Mohammed S. Ahmed  
*Sohag Teaching Hospital*

Rasha G. El-Din Abu-El-Goud  
*Sohag University, rg3943551@gmail.com*

Follow this and additional works at: [https://jmisr.researchcommons.org/home](https://jmisr.researchcommons.org/home)

Part of the Medical Sciences Commons, and the Medical Specialties Commons

**Recommended Citation**  
DOI: [https://doi.org/10.4103/jmisr.jmisr_47_22](https://doi.org/10.4103/jmisr.jmisr_47_22)

This Original Study is brought to you for free and open access by Journal of Medicine in Scientific Research. It has been accepted for inclusion in Journal of Medicine in Scientific Research by an authorized editor of Journal of Medicine in Scientific Research. For more information, please contact m_a_b200481@hotmail.com.
Effect of pattern-diode laser on central macular thickness and ganglion-cell complex after application in management of clinically significant macular edema

Mohammed S. Ahmed*, Rasha G. El-Din Abu-El-Goud*
*Department of Ophthalmology, Sohag Teaching Hospital, *Department of Family Medicine, Faculty of Medicine, Sohag University, Sohag, Egypt

Abstract

Background
Blindness is the end result of diabetic macular edema (DME). A 577-nm diode laser is the most frequently used one in ophthalmology. This study aimed to assess the effect of grid-diode laser application on the central macular thickness and ganglion-cell complex in management of clinically significant macular edema.

Methods
This study was performed on 95 eligible eyes. Complete ophthalmologic examination was performed, including best-corrected visual acuity with the use of ETDRS charts, measuring intraocular pressure, using slit lamp for biomicroscopic examination, fluorescein angiography, and fundus examination. Follow-up examinations, with complete ophthalmologic examination, were scheduled at 1 and 3 months after grid-diode laser application.

Results and conclusions
The study revealed significant improvement in the visual acuity after 3-month follow-up as well as significant decrease in central macular thickness and ganglion-cell complex at both 1- and 3-month follow-up visits. And in conclusion, an 810-nm grid-diode laser can be considered as an effective treatment for DME with improvement in visual acuity and reduction in thickness on optical coherence tomography. However, longer follow-up periods are needed to confirm the benefit of a 577-nm diode laser for DME. Its effect in previously untreated eyes needs also to be assessed in a randomized trial against other current treatment options, including conventional argon laser.

Keywords: Central macular thickness, diabetic macular edema, diode laser, ganglion-cell complex, grid-laser treatment

Effect of pattern-diode laser on central macular thickness and ganglion-cell complex after application in management of clinically significant macular edema

Mohammed S. Ahmed*, Rasha G. El-Din Abu-El-Goud*
*Department of Ophthalmology, Sohag Teaching Hospital, *Department of Family Medicine, Faculty of Medicine, Sohag University, Sohag, Egypt

INTRODUCTION

Diabetic retinopathy (DR) represents the main vascular complication in the retina of diabetic population and is considered a primary causative factor of visual impairment globally [1].

As reported by Diabetic Retinopathy Study Group (DRS), severe visual loss with acuity less than 5/200 can occur in 37% of untreated cases. High risk of proliferative diabetic retinopathy (PDR) is present within 6 years [2]. Ganglion-cell analysis algorithm of Cirrus optical coherence tomography (OCT) measures the thickness of the macular ganglion cell–inner-plexiform layer. Excellent reproducibility is present in-between visits [3].

Diabetes has a degenerative effect on nonvascular cells of the retina. It causes apoptosis of ganglion cells of the retina [4].
was proved that diabetes-induced biochemical mechanisms are the underlying cause of neural-cell degeneration [5]. In addition, numerous studies have reported that metabolic-pathways changes with diabetes induce functional and histopathological changes in the retina with even loss of different types of retinal cells, including ganglion cells, bipolar cells, and eventually photoreceptors [6].

Diabetic macular edema (DME) is a primary cause of visual loss in diabetic patients [7]. Macular edema is defined as retinal thickening or hard exudates at or within 1-disc diameter of the macula center. DME is classified into two types: a clinically significant macular edema (CSME) and clinically insignificant types. CSME has one of these criteria at least: thickening of the retina at 500 µm in the center of the macula or within it, hard exudates 500 µm in the center of the macula or within it if associated with thickening of adjacent retina. Do not count hard exudates that remain after improvement of retinal thickening or any zone of thickened retinal 1-disc area or more or any part within the 1 disc in the center of the macula [8].

OCT is used to visualize retinal and choroidal pathological changes and new generation provides higher resolution and faster measurement [9]. It also can detect retinal nerve-fiber-layer thickness directly via visualization of the retina [10].

One of the most widely used lasers in ophthalmology is the 810-nm semiconductor diode [11], which is near to the infrared range of the spectrum. The 810-nm wavelength is characterized by its ability to deeply penetrate into the choroid and can spare the inner neurosensory retina mainly affecting the deeper retinal layers, which is indicated for treatment in areas near the avascular zone of the fovea [12]. The localized photothermal effects reduce risks of both hemorrhage and the resulting thermal damage [13,14]. Furthermore, sparing the neurosensory retina will reduce posttreatment scarring and paracentral scotoma occurrence [15]. The deep penetration reaching the choroid is beneficial for cases of central serous chorioretinopathy. However, sensation of pain is a problem during treatment with a diode laser, the 810-nm laser [16], which is not seen with the micropulse mode [17].

Diode (577 nm) laser is applied via a series of repetitive short pulses separated by a long off-time after each pulse, which reduces the heat-produced tissue after conventional laser; a sublethal effect on the retinal pigment epithelium (RPE) is achieved. Photoreceptors are preserved with the neurosensory retina. Subthreshold micropulse laser may be comparable to standard laser, with reduced side effects. Subthreshold micropulse laser reduces variability because it is less dependent on the personal skills. Foveal burn is avoided if subthreshold micropulse laser is used [18]. Photocoagulation at the level of the retina, leading to protein denaturation, is the underlying mechanism in laser therapy either from direct action on blood vessels, which diminishes leakage or from increased oxygenation of the inner retina after burns of the RPE and photoreceptors. Cytokine production and reduction of vascular endothelial growth factor due to RPE activation with photocoagulation injury also have a role. This suggests that nondamaging type of laser treatment can promote retinal rejuvenation [19]. These changes are associated with an increase in leukocyte infiltration in the entire retinal layer. In addition, there is a significant reduction in the retinal nerve-fiber-layer thickness with degeneration of neurons as a result of glycosylation end products of diabetes [20].

Grid-laser treatment can improve macular edema. In total, 100–250 µm spots are applied to the posterior pole, one to two groups apart with sparing of the avascular zone of the fovea. Long-wavelength types of laser, such as krypton red and diode, are most used to perform grid laser. The grid technique improves blood retinal barriers via proliferation of pigment epithelial cells and proliferation of endothelial cells in retinal capillaries followed by coagulative necrosis-releasing factor [21].

This study was conducted to assess the effect of macular grid by diode-laser (577 nm) application on the central macular thickness (CMT) and ganglion-cell complex (GCC) in management of CSME.

**Patients and Methods**

Time frame: this study was conducted during the period from January 2020 to January 2022. The study protocol received approval from our Institute Review Board. Administrative approval and official permissions were obtained before data collection. Informed written consent was obtained from patients included in the study following the guarantee of data confidentiality to them.

Study population: this study was conducted on 95 eligible eyes in 95 consecutive patients who attended at the Ophthalmology Outpatient Clinic at Sohag Teaching Hospital during the study period.

Inclusion criteria:

NPDR patients with CSME defined by ETDRS by the presence of one of these criteria:

1. CMT from 250 to 400 µm.
2. Mild-to-moderate intraretinal microangiopathy in at least one quadrant.
3. Capillary dropouts in more than one quadrant.

Exclusion criteria: the following patients were excluded from the study:

1. Advanced and high-risk PDR or PDR.
2. Patients with densely opaque media (such as cataract or vitreous hemorrhage).
3. Patients with glaucoma.
4. Patients with hypertensive retinopathy or other retinopathies.
5. Patients who were treated by argon laser before.
6. Patients who underwent vitrectomy.

**Methods**

1. Cases were assessed pre-laser ttt. History taking included detailed medical history and detailed ocular history.
A complete ophthalmologic examination was performed, including best-corrected visual acuity (BCVA) with ETDRS charts, measuring intraocular pressure, slit-lamp biomicroscopy, fundus examination, and fluorescein angiography.

(2) GCC and CMT scanning procedures: by the same quality index. OCT macular scan and GCC scan were performed using glaucoma module by measuring the GCC. It uses raster scanning of a 7-mm² area on the fovea centralis, scan density was 128 (horizontal)×512 (vertical) scans. GCC is measured by machine in the form of superior, inferior, and average.

(3) Macular grid (using a 577-nm diode laser machine Quantel Easy et) was performed by applying laser burns around macular arcades with papillomacular bundle sparing at temporal and nasal areas without laser (so we compare using superior, inferior, and average ganglion-cell measurements). It was performed in one session; it was done using the slit-lamp delivery system and the Volk Area centralis (>0.94) lens.

(4) Laser burns were applied (by a 577-nm diode laser machine) around macular arcades 50 μm away from the disc. Laser settings were spot size = 100–200 µxcontact-lens magnification factor, duration = 0.1–0.2 s, power = 150–250 mW (sufficient to produce mild-to-moderate intensity/gray–white burns), fluence (J/cm) from 6.5 to 7.5 J/cm, and number of shots between 100 and 200. The burns were placed one to two spot sizes apart.

Volk area centralis (>0.94) lens. This is a contact lens that provides excellent ophthalmoscopic resolution, image binocularity, and real magnification to macular central area. Image magnification is >0.94. It is used to assess and treat retinal vascular diseases. Focal laser treatment allows magnification with an excellent field of view. The area centralis lens is in the range of motion of slit-lamp biomicroscopy without compromising of the binocular image or stereopsis.

(5) Follow-up protocol: about 1 and 3 months after diode-laser application by complete ophthalmologic examinations and OCT at each follow-up visit.

**Statistical analysis**

Data were collected, then coded, tabulated, and analyzed using Statistical Package for Social Science (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). The results were expressed as mean and SD for numerical values and the normality of the distribution of the study sample was assessed by means of the Shapiro–Wilk test. *t* test for paired comparison was used for the comparison of the two paired groups. The confidence interval: 95% and the margin of error: accepted to 5%. *P* value was significant if less than 0.05.

**Results**

Ninety five eligible eyes in 95 consecutive patients were enrolled in the current study. Their demographic data and clinical characteristics are shown in Table 1.

### Table 1: Patient demographic data and clinical characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>95</td>
</tr>
<tr>
<td>Number of eyes</td>
<td>95</td>
</tr>
<tr>
<td>Age (years)</td>
<td>54.93±9.27</td>
</tr>
<tr>
<td>Sex</td>
<td>Male 37 (38.9), Female 58 (61.1)</td>
</tr>
<tr>
<td>Medical history</td>
<td>Diabetic 67 (70.5), Diabetic-hypertensive 28 (29.5)</td>
</tr>
<tr>
<td>Ocular history</td>
<td>Left 49 (51.6), Right 46 (48.4)</td>
</tr>
</tbody>
</table>

*Values: as mean±SD. *Values: as n (%).

### Table 2: Changes in best-corrected visual acuity within follow-up

<table>
<thead>
<tr>
<th></th>
<th>Baseline mean±SD</th>
<th>3-month mean±SD</th>
<th>Paired t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCVA</td>
<td>0.21±0.09</td>
<td>0.52±0.19</td>
<td>-22.442</td>
</tr>
</tbody>
</table>

BCVA, best-corrected visual acuity.

**Changes in best-corrected visual acuity**

Follow-up BCVA revealed a very highly statistically significant (*P < 0.001*) improvement in the mean BCVA at 3 months compared with its baseline value (Table 2).

**Changes in central macular thickness**

Follow-up CMT revealed that the mean CMT decreased at 1 month with further decrease at 3 months after laser application and that these decreases in the mean CMT at 1 and 3 months after laser application were very highly statistically significant (*P < 0.001*) when compared with its baseline value (Table 3).

**Changes in ganglion-cell complex count**

Follow-up of GCC count within the follow-up period revealed that the mean values of superior, inferior, and average GCC count decreased at 1 month after laser application and then increased at 3 months after laser application, but without coming back to their baseline values. Meanwhile, very highly statistically significant (*P < 0.001*) decreases were found in the mean GCC count (superior, inferior, and average) at both 1 and 3 months when compared with their baseline values (Table 4).

Prediode laser OCT (CMT image, GCC images), case 1.

fx1
fx2
Three-months postdiode-laser OCT (CMT image, GCC image), case 1.

fx3
fx4
Table 3: Changes in central macular thickness within the follow-up period

<table>
<thead>
<tr>
<th></th>
<th>Baseline mean±SD</th>
<th>1-month mean±SD</th>
<th>3-month mean±SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMT</td>
<td>371.83±32.53</td>
<td>289.24±16.87</td>
<td>252.22±19.22</td>
<td>28.258</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39.935</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

CMT, central macular thickness. *Comparisons between scores measured at the baseline and the first month of follow-up.

Table 4: Changes in ganglion-cell complex count within the follow-up period

<table>
<thead>
<tr>
<th>GCC count</th>
<th>Baseline</th>
<th>1 month</th>
<th>3 months</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>115.42±7.19</td>
<td>105.35±8.02</td>
<td>108.86±6.76</td>
<td>29.299</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.428</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>Inferior</td>
<td>105.13±6.81</td>
<td>95.28±7.03</td>
<td>98.73±7.19</td>
<td>31.026</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.004</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>109.98±6.78</td>
<td>100.08±7.21</td>
<td>103.49±6.49</td>
<td>32.293</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.371</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as the mean±SD.GCC, ganglion-cell complex. *Comparison between scores measured at the baseline and the first month of follow-up.

Discussion

DME is a serious complication of DR [22]. ETDRS trial [23] reported that laser photocoagulation decreased the risk of blindness by 50% of cases of CSME. Treatment pattern depends on the pattern of edema. Grid pattern is used for a diffuse macular edema. Side effects can occur with continuous-wave photocoagulation, including epiretinal fibrosis [24–26]. This prospective interventional case series was conducted to assess the effect of grid-diode laser application on the CMT and GCC in management of CSME.

This study evaluated macular grid- (810-nm) diode laser in treatment of DME. There was a statistically significant improvement in BCVA at the 3-month follow-up. In terms of the CMT and GCC count on OCT, there was a decrease in the thickness in all follow-up visits, but it was of statistical significance at the 1- and 3-month visits.

The effect of diode-laser treatment in improvement of visual acuity and decreased thickness in DME was reported in previous studies [27–29] in which an additional advantage of micropulse diode laser treatment over conventional laser was reported as its application was not associated with damage in the layers of the retina.

Luttrull and Sinclair [30] used a micropulse laser in patients with center involving DME treated with subthreshold diode micropulse laser for fovea involving DME. They reported significant improvement in visual acuity and fovea central thickness during follow-up without any evidence of laser-induced macular damage. They concluded that a trans-foveal subthreshold diode micropulse laser was efficient for the treatment of fovea involving DME. Still, this study does have some limitations, notably a short follow-up duration. Similar studies are needed to confirm the benefit of a 810-nm diode laser for DME with longer follow-up periods. Its effect in previously untreated eyes needs to be assessed in a randomized trial against current treatment options such as conventional argon laser.

Conclusion

In conclusion, a 577-nm grid-diode laser can be considered as an effective treatment for DME with improved visual acuity and decreased edema on OCT with mild harmful effect on GCC.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References