Microsecond yellow laser for subfoveal leaks in central serous chorioretinopathy

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Purpose: To evaluate the role of navigated yellow microsecond laser in treating subfoveal leaks in nonresolving central serous chorioretinopathy (CSC).

Methods: This prospective study included ten eyes of ten consecutive patients with nonresolving CSC with subfoveal leaks. All eyes were treated with 577 nm navigated yellow microsecond laser (5% duty cycle). Key inclusion criteria include a vision loss for a duration of minimum 3 months due to focal subfoveal leak on fluorescein angiography. Key exclusion criteria include prior treatment for CSC and any signs of chronic CSC. Comprehensive examination, in addition to low-contrast visual acuity assessment, microrimetry, autofluorescence, spectral domain optical coherence tomography, and fundus fluorescein angiography, was done at baseline, 1, 3, and 6 months after treatment. Rescue laser was performed as per predefined criteria at 3 months.

Results: The average best-corrected visual acuity improved from 73.3±16.1 letters to 75.8±14.0 (P=0.69) at 3 months and 76.9±13.0 (P=0.59) at 6 months, but was not statistically significant. Low-contrast visual acuity assessment (logMAR) improved from 0.41±0.32 to 0.35±0.42 (P=0.50) at 3 months and 0.28±0.33 (P=0.18) at 6 months. Average retinal sensitivity significantly improved from baseline 18.93±7.19 dB to 22.49±6.77 dB (P=0.01) at 3 months and 21.46±8.47 dB (P=0.04) at 6 months. Rescue laser was required only in one eye at 3 months; however, laser was required in three eyes at 6 months.

Conclusion: Microsecond laser is a safe and effective modality for treating cases of nonresolving CSC with subfoveal leaks.

Keywords: CSC, central serous chorioretinopathy, Navilas®, navigated laser, microsecond yellow laser

Introduction

Central serous chorioretinopathy (CSC), a common chorioretinal disorder, is characterized by serous retinal detachment in the macula and often associated with serous pigment epithelial detachments. It is known to be self-resolving in many cases.1 But refractoriness to treatment and chronicity are known to cause permanent diminution in visual acuity.2-4 Such refractory cases are conventionally managed with focal laser. However, conventional laser cannot be applied in subfoveal and juxtafoveal leaks as it carries the risk of central or paracentral scotomas, accidental foveal burn, and choroidal neovascularization.5,6 Photodynamic therapy is a viable option in these cases, but it carries its own inherent risk of retinal pigment epithelium (RPE) atrophy, choroidal neovascularization, and choriocapillaris ischemia.7-11 Other treatment options include antivascular endothelial growth factors and oral medications.

The micropulse laser differs from conventional thermal laser in that it delivers laser only during 5%-15% of duty cycle and therefore prevents collateral thermal damage to the retinal tissue.12,13 The mechanism of action of micropulse laser induces...
metabolic effects through the production of mediators with an antiangiogenic and antiedematous action.\textsuperscript{14,15} These properties qualify the micropulse laser to be tried in the treatment of subfoveal and juxtafoveal leaks in CSC.

A more recent type of micropulse laser is the 577 nm yellow navigated laser (microsecond laser), which could be used to treat subfoveal and juxtafoveal leaks in CSC by titrating the power to a subthreshold level and delivering the laser in micropulse mode. In the present study, we prospectively studied the effect of 577 nm yellow micropulse navigated laser in treating eyes with persistent CSC with subfoveal leaks.

**Methods**

A prospective study was carried out at the L. V. Prasad Eye Institute, Hyderabad, India to evaluate the effect of microsecond laser in treating cases of CSC with subfoveal leaks. Institutional review board approval (L. V. Prasad Eye Institute ethics committee 12-14-120) was obtained for carrying out the study. After detailed explanation of the protocol, all patients signed a formal consent.

The inclusion criteria were: 1) age ≥18 years; 2) vision loss for a duration of minimum 3 months due to persistent CSC diagnosed by the presence of subretinal fluid (SRF) at the fovea and verified by spectral domain optical coherence tomography (SD-OCT);\textsuperscript{16} 3) focal subfoveal leak on fundus fluorescein angiography (FFA), defined as a leak within 500 μm from the center of fovea.

The exclusion criteria were: 1) history of prior treatment for CSC; 2) absence of any leak or any leak present in addition to the subfoveal leak on FFA; 3) diffuse leak on FFA, RPE atrophy, or any other signs of chronic CSC; 4) vitreoretinal/macular disorders other than CSC currently or in the past; 5) any intraocular procedure in the past 6 months; 6) currently on systemic or topical steroid therapy; 7) any significant media opacity; 8) history of malignant hypertension; 9) pregnancy; 10) currently on any systemic medication such as pioglitazones, which could cause macular edema; 11) evidence of glaucoma; and 12) spherical equivalent ≥±6D.

A detailed ocular history (onset of symptoms and previous treatment), the demography (age and sex), laterality, and systemic comorbidities (diabetes and hypertension) were recorded. A comprehensive ocular examination was done which included an assessment of the best-corrected distance visual acuity (BCVA) by Early Treatment Diabetic Retinopathy Study (ETDRS) chart, low-contrast visual acuity using COMPlog (24 in widescreen secondary monitor with display resolution of 1,920×1,080, in a dark room), and Amsler grid test before dilatation; spherical equivalent of refractive status of the eye; slit lamp biomicroscopy with a noncontact lens; and indirect ophthalmoscopy. Color fundus photographs of the optic disc, macula, and temporal retina (30°) were captured with a mydriatic camera (Zeiss FF450, Carl Zeiss Meditec, Jena, Germany).

**FFA**

FFA was performed using fluorescein sodium 20% and imaging on Navilas® system (OD-OS GmbH, Teltow, Germany) to determine the site of leakage at baseline, and at 3 and 6 months from baseline.

**SD-OCT**

The SD-OCT scans were obtained by using Cirrus HD-OCT (Carl Zeiss Meditec, Inc., Dublin, CA, USA) after dilatation of pupil with 0.8% tropicamide and 5% phenylephrine eye drops at every visit. The scanning protocol included HD5 line raster, HD single line raster, enhanced depth imaging, and macular cube. Central macular thickness (CMT) was determined automatically and analyzed by OCT software, by generating images using the macular cube 512×128 scan over 6×6 mm area, the cube being composed of 128 horizontal examination lines of 512 A-scans each. The CMT was obtained from the 1 mm central retinal thickness area as described in the ETDRS fields corresponding to the CMT.\textsuperscript{17}

The subfoveal choroidal thickness (CT) was measured using the enhanced depth imaging-OCT technique previously described by Spaide et al.\textsuperscript{18} The vertical distance between the hyper-reflective line of Bruch’s membrane and the innermost hyper-reflective line of the choriocapillaris interface was taken, and the average of the two scans (vertical and horizontal) was regarded as the subfoveal CT. The height of neurosensory detachment (NSD) was measured by the vertical distance between the outermost hyper-reflective margin of the detached neurosensory retina and the hyper-reflective line of the RPE. Scans with a signal strength of ≥6 were used for analysis.

**Autofluorescence**

Autofluorescence imaging of the posterior pole (30 degrees; using the Heidelberg retinal angiograph 2 unit, Heidelberg Engineering GmbH, Dossenheim, Germany) was done using the autofluorescence filter.

**Microperimetry**

Microperimetry (MAIA™, Centervue, Padova, Italy) was performed monocularly without mydriasis to assess the retinal sensitivity (RS). The size of the fixation target was selected
based on the subject’s visual acuity. If visual acuity was<br><|n|6/19.5 (0.50 logarithm of the minimum angle of resolution [logMAR]), then the larger fixation target was selected. The<br>100 grid pattern was selected in the protocol to test the 5° visual field surrounding the preferred retinal loci, which is<br>determined initially by the machine by showing only fixation<br>target for 10 seconds. The machine tests the retinal thresholds<br>at 37 points across the 50 visual fields using 4-2-1 staircase<br>procedure. Eye with better visual acuity was tested first, fol-
lowed by the fellow eye. Based on the reliability index, the<br>subjects were asked to repeat the test on the same day when-
ever necessary. Test was paused whenever the patient felt tired.<br>Microperimetry was done at baseline, and at 1, 3, and 6 months<br>from baseline. Using the registration ability of the MAIA®, RS<br>was checked at the same points at follow-up visits.

**Microsecond laser**

Treatment planning was done using the earliest phase of FFA<br>on Navilas system that showed the leaking spot. Initially, the<br>power of 577 nm yellow laser was titrated to just produce a<br>mild retinal whitening outside the vascular arcade, using <br>5% duty cycle, “test” spot size of 100 µm and 0.1 second<br>exposure time. Following this, the navigated microsecond<br>laser was used to place a 5x5 grid of confluent spots over the<br>area of focal leak, using the same settings with 30%<br>threshold power.

**Rescue laser**

Rescue microsecond laser, with the same settings as in<br>primary laser treatment, was applied at the site of leakage if<br>there was no change or if there was an increase in NSD on<br>SD-OCT at 3 months from baseline.

**Outcome measures**

Primary outcome measures included change in BCVA and<br>low-contrast visual acuity at 6 months follow-up compared to<br>baseline. Secondary outcome measures included resolution
of NSD, change in RS, and change in CT at the 6-month<br>follow-up compared to baseline.

**Statistical analysis**

The BCVA and low-contrast visual BCVA were calculated as<br>ETDRS visual acuity score in the form of number of letters. The<br>changes from baseline in BCVA; height of NSD, CMT, CT; and the average retinal threshold at 1, 3, and 6 months<br>were analyzed with Wilcoxon signed-rank test. P-value of <0.05 was regarded as statistically significant.

**Results**

We evaluated ten eyes of ten male patients with treatment-
naive persistent CSC, with a mean age of 38.2±4.37 years.<br>Average duration of symptoms was 7.2±4.3 months. All<br>ten eyes showed subfoveal leak on FFA and no other site of<br>leakage was observed. The overall features of the ten eyes at<br>baseline and after follow-up are summarized in Table 1, and<br>those of individual eyes are summarized in Table 2. All eyes<br>were phakic. Figure 1 demonstrates a representative case.<br>All ten eyes were treated with a sitting of microsecond laser<br>at baseline. The laser power used in our study ranged<br>from 120 to 280 mW. There was an improvement in the BCVA<br>from 73.3±16.1 ETDRS letters at baseline to 75.8±14.0<br>(P=0.69) letters at 3 months and 76.9±13.0 (P=0.59) letters<br>at 6 months, but the change was not statistically significant<br>at any visit. Similarly, the low-contrast BCVA improved from<br>79.7±18.73 letters at baseline to 86±16.30 letters at 6 months,<br>but not statistically significant (P=0.18). However, the<br>average RS on microperimetry was significantly improved<br>from baseline 18.93±7.19 dB to 22.49±6.67 dB (P=0.01) at<br>3 months and 21.46±8.47 dB (P=0.04) at 6 months.<br>At 1 month, there was total resolution of SRF in four<br>(40%) eyes and reduction in the NSD height in all the<br>remaining eyes.<br>At 3 months, six eyes (60%) had no SRF. Of the remain-
ing four eyes, only one eye did not show a progressive

**Table 1 Baseline parameters and changes in follow-up after microsecond laser therapy**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>1 month</th>
<th>3 months</th>
<th>6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average BCVA (ETDRS letter score ± SD)</td>
<td>73.3±16.1</td>
<td>73.1±16.3 (P=0.97)</td>
<td>75.8±14.0 (P=0.69)</td>
<td>76.9±13.0 (P=0.59)</td>
</tr>
<tr>
<td>Low-contrast BCVA (logMAR)</td>
<td>0.41±0.32</td>
<td>0.35±0.42 (P=0.50)</td>
<td>0.45±0.56 (P=0.69)</td>
<td>0.28±0.33 (P=0.18)</td>
</tr>
<tr>
<td>Average retinal sensitivity (dB) ± SD</td>
<td>18.93±7.19</td>
<td>18.82±8.46 (P=0.16)</td>
<td>22.49±6.67 (P=0.01)*</td>
<td>21.46±8.47 (P=0.04)*</td>
</tr>
<tr>
<td>Average CMT (µm) ± SD</td>
<td>298±128.58</td>
<td>199.9±71.77 (P=0.01)*</td>
<td>178.9±52.88 (P=0.01)*</td>
<td>214.9±90.10 (P=0.03)*</td>
</tr>
<tr>
<td>Average NSD height (µm) ± SD</td>
<td>151.8±110.20</td>
<td>57.5±65.52 (P=0.01)*</td>
<td>24±39.55 (P=0.01)*</td>
<td>62.6±91.88 (P=0.01)*</td>
</tr>
<tr>
<td>Average subfoveal CT (µm) ± SD</td>
<td>237±62.09</td>
<td>220.7±46.09 (P=0.14)</td>
<td>204.9±43.12 (P=0.07)</td>
<td>205.7±36.11 (P=0.03)*</td>
</tr>
</tbody>
</table>

**Notes:** *Statistically significant when compared to baseline. All P-values are with respect to baseline.<br>**Abbreviations:** BCVA, best-corrected visual acuity; CMT, central macular thickness; CT, choroidal thickness; ETDRS, Early Treatment Diabetic Retinopathy Study; logMAR, logarithm of the minimum angle of resolution; NSD, neurosensory detachment; SD, standard deviation.
**Table 2** Features of individual study eyes at baseline and at 6 months

<table>
<thead>
<tr>
<th>Case number</th>
<th>Age (years)/sex</th>
<th>Eye</th>
<th>Disease duration (months)</th>
<th>Baseline visit</th>
<th>6-month visit</th>
<th>Laser advised at last visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38/M OS 12</td>
<td>70</td>
<td>20/100 Low-contrast BCVA</td>
<td>112 Subfoveal CT (µm)</td>
<td>16.1</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>39/M OD 12</td>
<td>85</td>
<td>20/20 Low-contrast BCVA</td>
<td>121 Subfoveal CT (µm)</td>
<td>16.3</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>42/M OS 12</td>
<td>80</td>
<td>20/60 Low-contrast BCVA</td>
<td>212 Subfoveal CT (µm)</td>
<td>16.2</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>38/M OS 3</td>
<td>85</td>
<td>20/50 Low-contrast BCVA</td>
<td>276 Subfoveal CT (µm)</td>
<td>16.2</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>30/M OS 8</td>
<td>85</td>
<td>20/25 Low-contrast BCVA</td>
<td>196 Subfoveal CT (µm)</td>
<td>16.4</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>45/M OD 3</td>
<td>58</td>
<td>20/126 Low-contrast BCVA</td>
<td>200 Subfoveal CT (µm)</td>
<td>17.3</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>35/M OD 4</td>
<td>35</td>
<td>20/25 Low-contrast BCVA</td>
<td>304 Subfoveal CT (µm)</td>
<td>17.1</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>43/M OD 3</td>
<td>80</td>
<td>20/40 Low-contrast BCVA</td>
<td>184 Subfoveal CT (µm)</td>
<td>17.7</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>36/M OD 12</td>
<td>85</td>
<td>20/20 Low-contrast BCVA</td>
<td>156 Subfoveal CT (µm)</td>
<td>17.5</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>36/M OS 3</td>
<td>70</td>
<td>20/60 Low-contrast BCVA</td>
<td>200 Subfoveal CT (µm)</td>
<td>17.4</td>
<td>No</td>
</tr>
</tbody>
</table>

**Abbreviations:** BCVA, best-corrected visual acuity; CT, choroidal thickness; ETDRS, Early Treatment Diabetic Retinopathy Study; NSD, neurosensory detachment; M, male; OS, oculus sinister; OD, oculus dexter.

**Safety**

No laser spots were visualized on any postlaser visits by biomicroscopy, SD-OCT, or on fundus autorefrancence. None of the patients had any laser-related complications.

**Discussion**

Subthreshold diode laser micropulse photocoagulation has been previously used in the management of CSC. However, it is less scattered compared to conventional 1064 nm laser and thus can deliver a more concentrated energy to juxtafoveal lesions. Moreover, this wavelength is absorbed by both melanin and oxyhemoglobin, as a consequence of which, it has a potential to treat subfoveal or juxtafoveal lesions. Furthermore, this wavelength is absorbed by the absorption spectrum of retinal xanthophylls, because (577 nm) wavelength has the advantage of not being within the absorption spectrum of 414/40.46% and 244/40.16%, respectively. At 6-month follow-up, this significantly reduced to 24.4/70.06% (P<0.05) for IS/OS junction loss and external limiting membrane loss at baseline, whereas mean segment/segment mean of IS/OS junction and external limiting membrane loss at baseline were 41.4/42.4% and 244/40.1% for IS/OS junction loss from 57.4/52 µm at baseline to 57.4/52 µm at 6 months.

There was a statistically significant thinning of choroidal height from 151.8/52 µm at baseline to 121.4/52 µm at 6 months.

Overall, the NSD height was significantly decreased from 237/17.7 µm at baseline to 199.9/17.7 µm at 0.01) at 6 months. Similarly, the CMT was significantly reduced from 208/12.8 µm at baseline to 178/9.28 µm at 0.01) at 6 months.

There was a statistically significant thinning of choroidal height at site. Of the remaining four eyes, two had shown recurrence of SRF after complete resolution at previous visit, and two eyes had extrafoveal pocket of SRF with an extrafoveal leak at that site. Of the two eyes, one was treated with microsecond laser at that site. Of the remaining four eyes, two had shown recurrence of SRF after complete resolution at previous visit, and two eyes had extrafoveal pocket of SRF with an extrafoveal leak at that site. Of the two eyes, one was treated with microsecond laser at that site. Of the remaining four eyes, two had shown recurrence of SRF after complete resolution at previous visit, and two eyes had extrafoveal pocket of SRF with an extrafoveal leak at that site. Of the two eyes, one was treated with microsecond laser at that site.
We used microperimetry to assess the RS which is a measure of the functional outcome after treatment with microsecond laser. When compared to microperimetry, the mere assessment of BCVA has been shown to underestimate the effectiveness of photodynamic therapy in the treatment of CSC. In our study also there was a significant improvement in the RS at 3 and 6 months from baseline, even though there was no statistically significant improvement in the BCVA and low-contrast BCVA. Previous studies have related RS on microperimetry to the status of the retinal microstructure on OCT after resolution of CSC. RS has been found to decrease with disruption in the RPE line and the IS/OS line, and found to be higher in eyes with intact IS/OS line and intact cone outer segment tips. Therefore, the improvement in the average retinal threshold in our study of eyes not only proves the improvement in the functional status of the retina, but also rules out structural damage to the retinal microstructure after microsecond laser.

We treated eyes that had SRF for a duration of 3 months or more. We found a rapid response in 40% of these eyes within 1 month and in 60% eyes within 6 months after treatment. It implies that microsecond laser was effective in treating these eyes, and the effect was not by chance. Two of the ten eyes, in which NSD resolved completely at 3 months, showed recurrence of SRF at 6 months and required second sitting of microsecond laser, the treatment outcome of which is yet to be evaluated. We infer that microsecond laser is effective in treating CSC with subfoveal leak but the condition may recur and require repeat laser.

Navilas, due to its ability of eye tracking and utilizing computerized laser planning on the FFA image on the same device, can perform precise targeted treatments and thus is a good alternative to the conventional manually directed laser photoagulation in CSC, especially for subfoveal and juxtafoveal leaks. This is all the more useful in case of micropulse laser, which does not cause visible burns. For future reference, the detailed treatment report obtained from Navilas provides the exact location of the previously applied laser spots, which do not cause visible scarring as they do in the case of conventional laser.

By using the enhanced depth imaging-OCT technique, it has been reported that subfoveal CT is increased in eyes with CSC compared to normal eyes. Our study showed a significant progressive thinning of subfoveal choroid after 6 months, which is again indicative of the gradual resolution of the condition after microsecond laser.

Limitations of our study include a small sample size, which can be explained by the rarity of occurrence of subfoveal leak as a cause of persistent CSC. We did not have a control arm as placebo. However, resolution of persistent eye.
fluid with a mean of 7-month duration after microsecond laser is unlikely to occur by chance. It has been reported that eyes with CSC start developing photoreceptor atrophy as early as 4 months after the onset of symptoms. Further studies are required to assess if earlier intervention can cause better visual outcome. We analyzed only the B scan to evaluate the reduction in SRF. An en-face OCT imaging could have been better to understand the overall reduction in size of SRF. However, B scan is the commonly used modality in clinical practice, rather than an en-face OCT.

**Conclusion**

Microsecond laser is a safe and effective modality for treating cases of nonresolving CSC with subfoveal leaks. We report significant improvement in RS after microsecond laser in spite of no significant benefit in visual acuity. However, repeat micropulse laser may be required for treating cases that have recurrence. Further studies with larger sample size and longer follow-up will explore the efficacy and outcome of retreatment with microsecond laser in this distinct situation.

**Disclosure**

The authors report no conflicts of interest in this work.

**References**
