

BRIEF COMMUNICATION

## Red light-emitting diode (LED) therapy accelerates wound healing post-blepharoplasty and periocular laser ablative resurfacing

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### Abstract

**Background and aims.** Blepharoplasties can be associated with sequelae-related patient downtime, often extended or reinforced by periocular laser ablative resurfacing. The present controlled study examined the effects of a new-generation LED phototherapy system on enhancing wound healing following such combination surgery.

**Methods.** Two males and eight females participated in the trial, with ages ranging from 44 to 59 years (average 52.3 years). Following blepharoplasty and Er:YAG/CO<sub>2</sub> laser ablative resurfacing, one-half of each subject's face was treated with the red LED therapy (20 min, 96 J/cm<sup>2</sup>, 633 nm), the contralateral half being the unirradiated control. Patients reported subjectively on pain levels and resolution. Resolution of erythema, edema, bruising and days to healing were independently evaluated from the clinical photography. All findings were compared between the treated and untreated sides.

**Results.** In all instances, the LED therapy-treated side was statistically significantly superior to the unirradiated control by a factor of two to three.

**Conclusions.** In this small series of 10 patients, red LED phototherapy after blepharoplasty and laser ablative resurfacing cut the time to resolution of side effects and the healing time by one-half to one-third compared with contralateral unirradiated controls. Further studies are warranted with larger populations to confirm these findings.

**Key words:** *Blepharoplasty, laser ablative resurfacing, light-emitting diodes, phototherapy, wound healing*

### Introduction

Lower eyelid blepharoplasty, particularly via the transconjunctival approach, is associated with minimal side effects and rapid healing. Upper eyelid blepharoplasty, on the other hand, is associated with more trauma and longer-lasting sequelae, such as bruising and edema, which can take several weeks to resolve. These procedures done in combination are very often followed by a periocular laser ablative skin resurfacing procedure, itself associated with several weeks of burn-related sequelae. Since the late 1960s, there have been reports in the literature regarding the application of low incident levels of laser energy, so-called laser therapy or LLLT, in the healing of torpid crural ulcers and in other wound healing applications (1–3). Laser therapy systems are punctal in application, however, so treating the entire area of a bilateral blepharoplasty and periocular resurfacing would be time-consuming. As a spin-off from the NASA Space Medicine program, a new generation of light-emitting diodes (LEDs) has become commercially available, with higher and much more

stable output powers, a spectral bandwidth of a few nanometers and a much less divergent beam than their predecessors (4,5). The present controlled study was designed to assess the usefulness of a red (633 nm ± 3 nm) LED therapy system in accelerating wound healing after blepharoplasties followed by periocular resurfacing.

### Subjects and methods

Ten subjects took part in the study: two males and eight females, ages ranging from 44 to 59 years (average 52.3 years), two with skin phototype II, five with skin phototype III and three with skin phototype IV (see Table I). The purpose of the study was explained to the subjects, and all subjects signed forms of informed consent to participate in the study, and for the taking of the clinical photography. The study was approved by the ethics committee of the Antoni de Gimbernat Foundation.

The LED-based system used was the Omnilux Revive (Photo Therapeutics, Fazely, UK), which

Table I. Patient characteristics and days to healing compared between the treated and contralateral untreated sides of the face.

Patient no.	Sex	Age	Days to healing		Skin type
			Treated <sup>a</sup>	Untreated <sup>a</sup>	
1	M	58	14	27	III
2	F	46	13	27	III
3	F	49	15	29	IV
4	F	57	12	26	IV
5	F	55	14	28	III
6	F	48	13	25	II
7	F	50	14	27	III
8	F	58	15	29	II
9	M	59	13	25	III
10	F	44	12	25	IV
Mean ± SE	–	52.4 ± 5.60	13.5 ± 0.34	26.8 ± 0.49	–

<sup>a</sup>Statistically significant difference between groups ( $p < 0.0001$ ).

delivers 633 nm light ( $\pm 3$  nm) at an incident power density of 80 mW/cm<sup>2</sup> and 96 J/cm<sup>2</sup> over a 20-minute treatment time. The active area of the head (approximately 400 cm<sup>2</sup>) consists of four

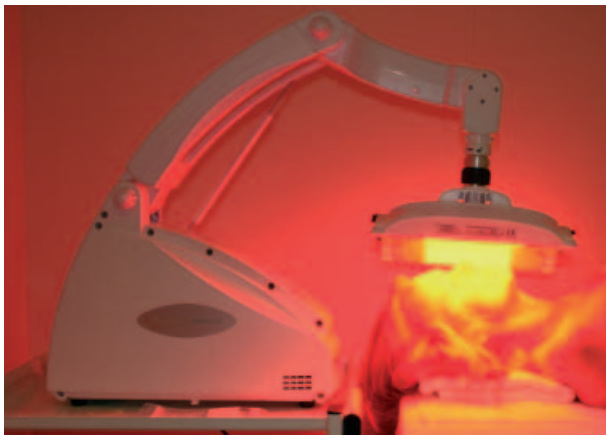


Figure 1. Omnilux Revive LED therapy system in action. The articulated arm enables adjustment of the treatment head over the desired target, and the ‘hands-off’ therapy approach allows the clinician to attend to other patients; for example, during the 20-minute treatment session.

hinged panels which can be arranged to follow the contour of the face, for example, and attached to the control console by an adjustable articulated arm. Figure 1 shows the system in operation.

In all subjects, the periocular laser resurfacing was carried out with the combined Er:YAG continuous wave CO<sub>2</sub> system in the authors’ technique, as has been reported previously (6).

In each of the subjects, one-half of the face was randomly assigned to be treated with the LED therapy system post-surgery, whereas the contralateral half was covered with an opaque shield to prevent the red light reaching the face on that side. The subjects wore no goggles during the irradiation sessions as full exposure of the upper eyelid and periocular area was necessary; however, a small self-adhesive seal was placed on the eye to be treated so patients were aware not to open their eyes. The emission levels are well within ocular safety requirements for that wavelength. Treatment sessions were 20 minutes each, performed immediately and at 48 hours after surgery, then twice during the following week. Subjects came in for assessment 24 and 48 hours after surgery, then at 7 days, 10 days,

Table II. Side effects and the days to their resolution, postoperative pain score (evaluated on a visual analog scale, VAS<sup>a</sup>) and the hours to the resolution of postoperative pain compared between the treated and contralateral untreated sides of the face.

Patient no.	Side effect, and days to resolution						Pain score <sup>a,b</sup> (VAS)		Hours to pain resolution <sup>b</sup>	
	Edema <sup>b</sup>		Erythema <sup>b</sup>		Bruising <sup>b</sup>					
	Tx	U	Tx	U	Tx	U	Tx	U	Tx	U
1	4	9	8	13	5	9	3	8	1	3.5
2	3	7	7	12	4	8	4	7	1.5	3
3	3	6	7	11	5	10	4	7	1	2
4	4	6	8	12	5	11	2	6	0.5	2.5
5	5	9	9	12	4	8	2	7	1	3
6	4	9	8	12	4	9	4	8	2	3.5
7	4	8	8	11	5	8	3	7	1	2
8	3	7	6	10	3	6	2	6	0.5	3
9	3	7	6	11	4	7	2	7	1	3.5
10	4	8	7	12	8	9	3	6	1.5	3
Mean (SE)	3.7 (0.21)	7.6 (0.37)	3.7 (0.23)	7.6 (0.39)	4.7 (0.42)	8.5 (0.45)	2.9 (0.28)	6.9 (0.23)	1.1 (0.14)	2.9 (0.18)

Tx=treated; U=untreated. <sup>a</sup>0=pain free; 10=extreme pain. <sup>b</sup>Statistically significant difference between groups ( $p < 0.0001$ ).

and 2, 3 and 6 weeks post-surgery, at which times clinical photography was performed. Subjects filled in a questionnaire to assess the level of pain post-surgery, and how long the discomfort took to go away. The clinical photography was assessed for the presence and evolution of sequelae (edema, erythema and bruising) and the time to complete healing by a blinded and independent plastic surgeon. The tabulated data were expressed as means plus or minus the standard error, and tested for statistically significant differences between the two sides with the two-sample *t*-test. A value of  $p < 0.05$  was considered significant.

## Results

All 10 subjects completed the trial. Table I shows the times to complete healing compared for the LED-treated and untreated periocular areas, with a mean (plus or minus the standard error) of  $13.5 \pm 0.34$  days for the former compared with  $26.8 \pm 0.49$  days for the untreated side. The difference was statistically significant ( $p < 0.0001$ ). Table II examines the objective assessment of the resolution of edema, erythema and bruising plus the patient's subjective assessment of pain immediately after the first postoperative LED session and the hours till pain resolution, all compared between the irradiated and unirradiated side. In every case there was a statistically significant difference in favor of the LED-treated side ( $p < 0.0001$  for all), with the treated side resolving two- to almost threefold faster compared with the unirradiated side.

Figure 2 shows a typical example of a patient (patient no. 7, a 50-year-old female) before (Figure 2A), 24 hours postoperatively (Figure 2B), 2 weeks (Figure 2C) and 6 weeks (Figure 2D) after the operation. At 6 weeks postoperatively there was no significant difference in the quality of the skin between the LED-irradiated and unirradiated side, but the much faster resolution of erythema, edema and bruising in the LED-treated side in the earlier stages of wound healing could be seen.

## Discussion

Before the development of the new LED sources by the NASA Space Medicine Program as reported by Whelan et al. (4,5), LEDs were not a suitable phototherapy source due to low and unstable output powers, high divergence and a waveband which could vary by as much as 100 nm either side of the rated wavelength. In the new generation of LEDs, these problems have been solved. When precisely mounted in panels, taking into account the angle of divergence, a quasimonochromatic beam ( $633 \pm 3$  nm in the system used in the current study) of high photon density is generated in the target

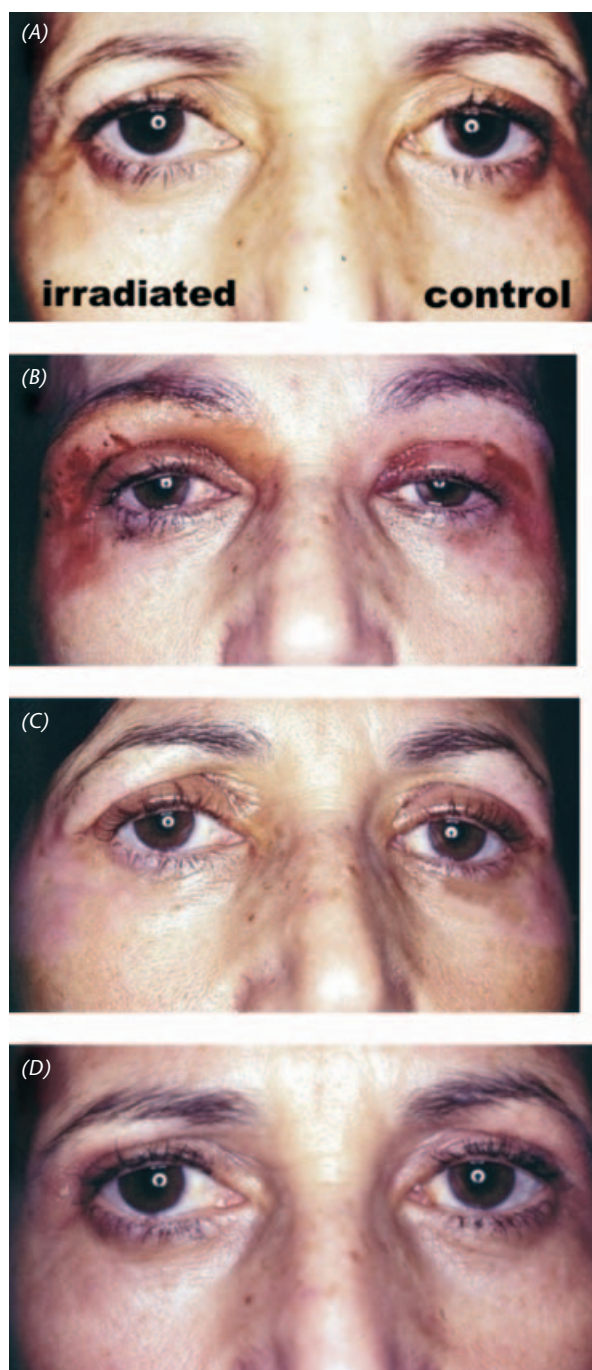


Figure 2. Fifty-year-old female patient before and at various stages after the operation: the right side of the face was irradiated with the red LED therapy system. (A) Pretreatment findings. (B) The condition 24 hours postoperatively. It would appear that the right side is actually worse than the left, but in fact the inflammatory stage of wound healing has been accelerated compared with the left. (C) Two weeks postoperatively, the condition of the right LED-irradiated side is much better than the left. (D) At 6 weeks postoperatively, not much difference could be seen between sides, but it appeared that red LED therapy post-blepharoplasty with periocular laser ablative resurfacing would enable faster return of the patient to his or her normal social or working life.

tissue due to the interaction between the beam of intense visible red light energy and the target tissue.

The wavelength of 633 nm is one whose interaction with cells and tissues has been well explored

in vivo and in vitro, since this is the wavelength of the helium neon (HeNe) laser which has a long tried and tested history in phototherapy (1–3; and works cited therein). The wound healing powers of this wavelength and its efficacy in pain attenuation have been well reported, as has the enhancement of local blood circulation. As the system used in the present study works in a non-contact, hands-off mode, it is ideal homogeneously to irradiate the large areas of controlled laser burn associated with laser ablative resurfacing, and can irradiate the patient's whole face in one exposure. The incident energy density of 96 J/cm<sup>2</sup> in continuous wave over the approximately 400 cm<sup>2</sup> active area of the LED panels is clinically useful and, because of the scattering pattern of 633 nm in tissue and the interference phenomenon between adjacent sets of LED beams, an intense photon density is created in the target tissue. This athermally modulates the target cell activities, controlling pain, draining edema and accelerating the wound-healing process, as demonstrated in the present article, with pain, edema and erythema times one-half to one-third those of the unirradiated side.

There are two limitations to the present study. The small number of patients does not allow any definitive statement to be made regarding the efficacy of red LED therapy in accelerating post-blepharoplasty and laser resurfacing wound healing in a wide range of patients, and the statistical power of the study is low. Secondly, the half-face model, whereby each subject acts as their own contralateral control, is essentially flawed as a model to prove or disprove any aspect of phototherapy. The 'systemic effect' has been extremely well reported, whereby photoproducts in the irradiated side are carried throughout the body by the blood and lymphatic systems so that the unirradiated side also benefits from the irradiation and is thus not a true 'unirradiated control'. However, as all subjects were treated in exactly the same way and at the same parameters, in this instance it is still an effective control model, but it is entirely possible that even the unirradiated side on the LED-irradiated subjects healed faster than a true unirradiated subject. This is a point for future examination.

To conclude, in this group of 10 patients we found that red continuous wave LED therapy following blepharoplasties combined with periocular laser ablative skin resurfacing cut the time to resolution of side effects and healing time by one-half to one-third. Although the final result was not different in the skin quality between the LED-treated and control sides, the much earlier resolution of sequelae on the LED-irradiated side suggested that patients may be able to return much faster to their normal social or working life following red LED therapy after combined blepharoplasty and laser ablative resurfacing.

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