



The Effect of Red Light-Emitting Diode at 633 Nanometers on Skin Wrinkles

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Abstract

There is growing interest for non-invasive and affordable procedures for skin rejuvenation in the recent years. Light-emitting diode (LED), a form of phototherapy, is one of the modalities that has been used for skin rejuvenation. Most of the studies had conducted on the facial skin, however, there are not many reports that determine the effectiveness of LED on other area on the body. The objective of this study was to evaluate the effect of red LED at 633 nanometers on the neck area. This was a pilot study conducted on 20 subjects aged 30 to 75 years' old who were interested in skin rejuvenation. All subjects underwent red LED treatment using Dr. Müller Beauty Light Therapy device twice a week for six weeks. Primary outcome measured in the study were the changes in neck skin wrinkles using Antera 3D®. Digital photographs were taken at baseline, week 4 and week 8 follow-up. The assessment was done at baseline, week 2, 4, 6, and 8 follow-ups. Subject's satisfaction score and adverse reactions were also recorded. All 20 subjects completed the study and attended all follow-up. The neck skin wrinkles analysis, using Antera 3D®, showed statistically significant improvement from 2-week follow-up onwards compared to baseline. Majority of the subjects (50%) scored good improvement on the neck skin at 8-week follow-up. No adverse reaction was reported. Red LED at 633 nm is safe and can be used as an adjunctive modality for skin rejuvenation

Keywords: *Light-Emitting Diode, Photorejuvenation, Skin Rejuvenation, Skin Wrinkles*

1. Introduction

Skin aging is a complex degenerative process that can be clinically observed as having wrinkles, dark spots, dryness, and sagginess. This process is contributed by both intrinsic and extrinsic factors. Intrinsic factor is mostly genetically influenced while extrinsic factors is mainly due to ultraviolet (UV) radiation, photoaged skin, or environmental factors (Zouboulis et al., 2019). Among the features of aging skin, wrinkle is the most noticeable characteristic that is caused by the reduction in skin collagen. Photoaged skin is found to have higher activity of matrix metalloproteinases (MMPs) type 1 which results in collagen degradation (Kim et al., 2015). There are a variety of approaches towards anti-aging methods especially minimally to non-invasive procedure such as laser, neurotoxins, filler or phototherapy.

Light-emitting diode (LED) is a form of phototherapy that is becoming more popular in dermatologic field in the recent years. The possible reasons are its nonablative, atraumatic, no recovery time and inexpensive procedures. It emits a narrow range of non-coherent low-level light which causes biological changes at a cellular level, also called photobiostimulation (PBMT), taken up by specific chromophores in the skin (Huang, Nguyen, Ho, & Jagdeo, 2020). The penetration depth is depending on the wavelength. The longer the wavelength, the deeper the light can penetrate. LEDs are available from 400 nm to 1200 nm (blue, yellow, red and near-infrared) (Opel et al., 2015).

Red LED was found to penetrate 2-3 mm in the dermis which cover fibroblasts up to the reticular dermis. The main mechanism involves in the stimulation of cytochrome c oxidase (CCO), a complex protein unit IV in the mitochondria transport chain, which synthesized adenosine triphosphate (ATP). This interaction enhances cellular activities, increase in oxygen consumption, gene expression, growth factors and cell proliferation resulting in skin rejuvenation (Van Tran, Chae, Moon, & Lee, 2021). Most of the studies that determined the efficacy of red LED on skin rejuvenation focused on the facial skin. However, the effect on other area on the body has yet to be explored. Lee et al. (2021) studied the safety and efficacy of a home-use LED device at 630 nm and 850 nm for neck rejuvenation. He and his colleagues found that

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the neck biophysical characteristics such as skin elasticity and hydration improved significantly with normal thyroid functions test and ultrasonographic assessment after 16 weeks of LED use suggesting that LED was safe and effective in neck skin rejuvenation.

2. Objectives

- 1) To evaluate the effect of red LED at 633 nm on skin's wrinkles using Antera 3D®
- 2) To evaluate the subject's satisfaction score for skin improvement
- 3) To evaluate any adverse reaction after the treatment

3. Materials and Methods

3.1 Study Design

This was a pilot study with a total of 20 subjects, aged 30 to 75 years old, with Fitzpatrick skin types II to V who had wrinkles on the body and were interested in skin improvement. Exclusion criteria were subjects who are pregnant or lactating, having local skin inflammation, having active herpes zoster infection, photosensitive dermatosis, history of botulinum toxin injection within 6 months on the neck area, history of filler injection, fat grafting, thread lifting or energy-based treatment within 1 year on the neck area. The study was approved by the Human Research Ethics Committee of Thammasat University (Medicine) (MTU-EC-OO-0-254/65). Informed consents were obtained from all subjects prior to their registration in the study.

3.2 Study device

The investigational device is Beauty Light Therapy (DR. MÜLLER, Hengelo, Netherlands) which gives non-invasive treatment for skin rejuvenation (Figure 1). The device is equipped with 48 red LED lamps with 633 nm wavelength, total irradiance of 32.64 mW/cm² and fluence of 23.5 J/cm². The operating time per treatment is 12 minutes. The device is available at Benchakitti Park hospital.

3.3 Study protocol

All subjects underwent twice treatment a week for 6 weeks for a total of 12 treatment sessions. The whole body was exposed to the red LED. The subjects were asked to stand still in the device chin up with or without holding the handle. Safety goggles was worn throughout the session to protect the eyes. The measurement area is at the neck using non-invasive device, Antera 3D®. Prior to treatment, subjects were asked to wash off any make up on the neck. The device was connected to the electrical port and was turned on. Each subject underwent red LED light irradiation for 12 minutes per treatment session. The clinical evaluation was obtained at baseline, 2-, 4-, 6-, 8- week follow-ups. Digital photograph obtained using Nikon D7000 with the same settings, upright front view position, same distance, and lighting at baseline, 4- and 8-week follow-ups.

3.4 Outcome assessment

The primary outcome was the changes in skin characteristics on the neck using noninvasive subjective instruments. Antera 3D® was used to assess the skin's wrinkles. Secondary outcomes included satisfaction score graded by the subjects evaluated using the four-point score scale: 0 = no improvement, 1 = mild improvement (1%-25%), 2 = moderate improvement (26%-50%), 3 = good improvement (51%-75%), and 4 = excellent improvement (76%-100%) at all follow-ups. Adverse reactions such as erythema, edema, or blurred vision were also recorded.



Figure 1 Dr. Müller Beauty Light Therapy device

3.5 Statistical analysis

The authors hypothesized that the treatment of red LED at 633 nm wavelength on skin wrinkles is different from before and after treatment. Descriptive analysis was used for the demographic data. Clinical data analyses included a comparison of results at different study times versus baseline. The repeated measures ANOVA will be carried out to compare changes in all parameters at each visit. Data were analyzed using SPSS software. *P*-values of <0.05 will be considered statistically significant.

4. Results and Discussion

4.1 Results

Twenty subjects (3 males and 17 females) who met the inclusion criteria were enrolled in the study. Most of the subjects (75%) had Fitzpatrick skin type III. All twenty subjects completed the whole study. The demographic data of the subjects are described in Table 1.

The objective assessment of skin wrinkles at the neck was done using Antera 3D® shown in Table 2. The skin wrinkles at the neck decreased significantly at 2-, 4-, 6-, and 8-week follow-up when compared to baseline ($p < 0.05$).

Subjective assessment from the subjects' satisfaction score for skin improvement was recorded on 2-, 4-, 6-, and 8-week follow-up as presented in Table 3. Subject' satisfaction score showed that majority of the subjects scored moderate to good at 2-, 4-, 6-, and 8-week follow-up. At 8-week follow-up majority (50%) of the subjects scored good skin improvement. The scores were statistically significant at $p < 0.05$ from week 6 to week 8 follow-up when compared to baseline.

During the study, all subjects (100%) reported to have smoother skin from 2-week follow-up onward. No adverse event was reported.

**Table 1** Demographic data of subjects enrolled in the study (n= 20)

Characteristics	Total, n (%) (n = 20)
Sex, n (%)	
Male	3 (15)
Female	17 (85)
Age (years), mean± SD (min-max)	50.1± 14.28 (31-70)
Fitzpatrick's skin type, n (%)	
Type II	2 (10)
Type III	15 (75)
Type IV	2 (10)
Type V	1 (5)

Abbreviation: SD, standard deviation

Table 2 Assessment of skin wrinkles at the neck using Antera 3D® from baseline to all follow-ups (n = 20)

Follow-up	Mean ± SD	Neck wrinkles		
		Mean change (95% CI)	% Change (95% CI.)	p-value
Baseline	17.28 ± 4.61	Reference	Reference	-
2-week	16.11 ± 4.47	-1.17 (-1.89, -0.45)	-6.48 (-10.68, -2.28)	0.003*
4-week	15.89 ± 4.53	-1.39 (-2.17, -0.62)	-7.87 (-12.52, -3.21)	0.001*
6-week	15.97 ± 4.49	-1.31 (-2.17, -0.44)	-7.2 (-11.87, -2.54)	0.005*
8-week	15.66 ± 4.52	-1.62 (-2.42, -0.82)	-9.38 (-13.72, -5.05)	<0.001*

*Statistically significant at $P < 0.05$ **Table 3** Subject's skin improvement score (n= 20)

Score	Percentage/ description	Subjects			
		2 weeks	4 weeks	6 weeks	8 weeks
0	0% No improvement	1 (5%)	0 (0%)	0 (0%)	0 (0%)
1	1-25% Mild improvement	7 (35%)	3 (15%)	0 (0%)	2 (10%)
2	26-50% Moderate improvement	11 (55%)	17 (85%)	8 (40%)	5 (25%)
3	51-75% Good improvement	1 (5%)	0 (0%)	11 (55%)	10 (50%)
4	76-100% Excellent improvement	0 (0%)	0 (0%)	1 (5%)	3 (15%)
	p-value	Reference	0.228	<0.001*	<0.001*

*Statistically significant at $P < 0.05$

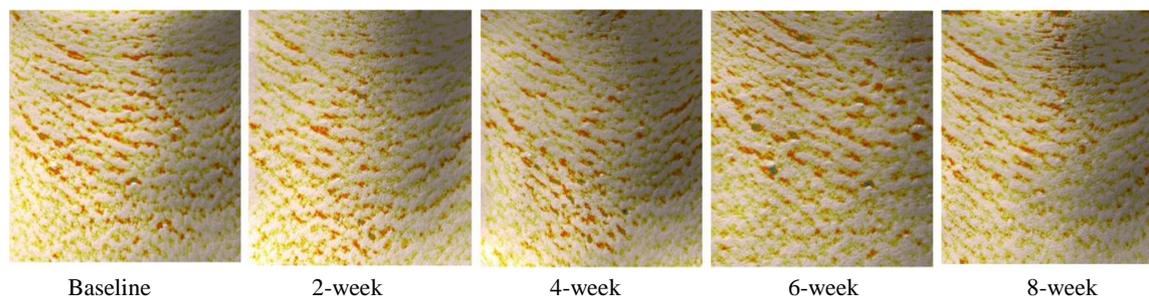


Figure 2 Changes in skin wrinkles on the neck using Antera 3D® from baseline, 2-, 4-, 6-, and 8-week follow-up



Figure 3 Changes in skin wrinkles on the neck using digital photograph from baseline, 4-, and 8-week follow-up

4.2 Discussion

Light-emitting diode has been used for various dermatologic conditions such as photoaging, acne, wound healing and hair loss (Barolet, 2008). The growing interest of phototherapy could be its non-invasive with no downtime procedure. Although its ability may not be superior to other methods like laser or toxin injection, but evidently, it has the positive effect as an anti-aging strategy.

LED uses low level light therapy to trigger biological changes that benefit the skin. It was reported both *in vitro* and *in vivo* studies that red LED could help in wound healing and aging skin. Irradiation with red LED at 633 nm was found to stimulate procollagen type 1 production and decreased MMP-1 and MMP-2 which resulted in skin rejuvenation (Kim et al., 2015). Sauder (2010) had done a review literature that used LED device for skin conditions. What he found was mainly the use of LED for facial wrinkles and acne treatment. However, very few studies have yet to explore its effect on other area of the body.

In our study, all subjects underwent red LED treatment for a total of 12 sessions. The results were analyzed objectively using Antera 3D® and have shown a significant decrease in neck skin wrinkles from week 2, 4, 6, and 8 follow-ups as compared to baseline. The percent changes comparing to baseline were -6.48%, -7.87%, -7.2% and -9.38% ($p < 0.05$) respectively. In figure 2 shows the Antera 3D® images of one subject presenting changes in neck skin wrinkles from baseline throughout all follow-up. We could see the gradual decrease in the dept of the wrinkles. Figure 3 shows the clinical photographs of a subject from baseline, week 4 and week 8 follow-up. All of the subjects reported to have smoother skin on the whole body and satisfied with the study. Thus, the results reported on this study shows that red LED at 633 nm is effective in skin rejuvenation.

A few limitations of this study were the sample size, the restriction to one study site, some people do not apply sunscreen or body lotion on a regular basis and no long-term study of its efficacy has been done.



5. Conclusion

After underwent the irradiation treatment with red LED have shown the reduction in neck wrinkles both objectively and subjectively. We could conclude that red LED at 633 nm is safe and can be used as an adjunctive modality for skin rejuvenation.

6. Acknowledgements

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