



Original Article

## Effects of low-level laser therapy, electroacupuncture, and radiofrequency on the pigmentation and skin tone of adult women

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**Abstract.** [Purpose] In this study, the effects of low-level laser therapy (LLLT), electroacupuncture (EA), and radiofrequency (RF), which are used in physical therapy, on the pigmentation and skin tone of adult women's faces were investigated to provide basic data for skin interventions. [Subjects and Methods] Thirty adult females were assigned to either an LLLT group (n=10), an EA group (n=10), or an RF group (n=10). The intervention was performed in two 15-minute sessions per week for six weeks. Subjects' skin tone and pigmentation were observed before and after the intervention. [Results] The EA group showed significant reductions in pigmentation in the left and right eye rims, as well as in the left cheek. The RF group showed significant post-intervention reductions in pigmentation under the left eye, as well as in the left and right eye rims and the left cheek. The LLLT group showed significant increases in skin tone in the forehead and both eye rims. The RF group showed significant increases in skin tone under both eyes. [Conclusion] The application of LLLT, EA, and RF had positive effects on pigmentation and skin tone of adult women's faces.

**Key words:** Low-level laser therapy, Electroacupuncture, Radiofrequency

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### INTRODUCTION

Studies related to anti-aging are currently being conducted actively around the world, and the related markets are growing fast. In particular, many studies are being conducted on delaying the skin aging process, as people have an increasing interest in changing their external form as well as the functional aspects of their bodies to increase their self-esteem<sup>1)</sup>. Furthermore, with the development of industry, interest in the effects of air contamination and environmental pollution on the skin and the body is rising, which has led to rising interest in scientific skin management and the introduction of various new skin care devices<sup>2)</sup>.

Skin aging can be classified into two categories: intrinsic aging which develops naturally with age, and aging caused by the external environment<sup>3)</sup>. Intrinsic aging appears as wrinkles, sagging, and pigmentation, whereas aging caused by the external environment, e.g. ultraviolet rays, wind, coldness, dryness, and tobacco, appears as skin roughness, vasodilatation, actinic keratosis, and solar lentigo, which are generated only in exposed regions<sup>4)</sup>. In particular, skin photo-aging by UV rays leads to acute reactions of erythema and edema, which increase the incidence of skin cancer and chronic reactions such as skin pigmentation. Such pigmentation appears when melanin pigments are synthesized excessively in melanin cells exposed to UV rays or when the physiological functions of the skin deteriorate. When this happens, pigments are deposited in the horny

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cells of the epidermis, which appear as melasma and freckles<sup>5</sup>). Various therapies to improve skin aging are being researched in dermatology, and various laser treatments, chemical peels, surgical treatments, fillers, and Botox are being used<sup>6-9</sup>).

The effects of low-level laser therapy (LLLT) include reduced inflammation, improved lymphedema, relief of pain, and accelerated cell metabolism and cell division, which promote skin regeneration and help facilitate wound healing. It is also effective in collagen generation, acne treatment, wrinkle improvement, and skin laxity<sup>10-16</sup>). Electroacupuncture (EA) has been reported to accelerate the healing of wound tissues, and to elicit anti-inflammation effects, wrinkle improvements, and the reduction of face edema<sup>17-19</sup>). Radiofrequency (RF) has been reported to be effective at reducing of wrinkles and in the treatment of acne scars by increasing blood circulation and promoting collagen generation, as well as reducing abdominal obesity<sup>11, 20-22</sup>).

This study was conducted to observe the effects of LLLT, EA, and RF, which are used in physical therapy, on the pigmentation and skin tone of adult women's faces to provide basic data on skin interventions.

## SUBJECTS AND METHODS

The subjects of this study were 30 adult women between 30 and 55 years of age who visited M Dermatology Hospital in Yongin, Gyeonggi-do, South Korea and who voluntarily agreed to participate after listening to an explanation of the purpose of this study. The subjects were assigned to a LLLT group, (n=10), an EA group (n=10), and an RF group (n=10). The intervention was performed in two 15-minute sessions per week for six weeks. Their skin tone and pigmentation were observed pre and post intervention. Inter-group homogeneity testing for general characteristics before treatment revealed no significant differences. Written informed consent was obtained from each subject. The Ethics Committee of Namseoul University, South Korea approved the study. The IRB approval number is Research-104147-201504-HR-003. The characteristics of the subjects are shown in Table 1.

For the LLLT group, RedPulsar (SOMETECH Inc., Korea), which is a diode laser, was used the treatment sessions. It is a class IIIb laser with a wavelength of 635 nm, and power output of 10 mW<sup>23</sup>). For the RF group, PRIX III (SHENB Co., Ltd, Korea) was used at a frequency of 1 MHz (RF energy, maximum 450 W/cm<sup>2</sup>) the treatment sessions<sup>24</sup>). For the EA group, disposable stainless steel acupuncture with a size of 0.20 × 15 mm was used. For the EA stimulator, an OTS H-306 (HANIL TM Co., Ltd., Korea) was used with operating conditions of a frequency of 3 Hz, 5 seconds of on time, and 2 seconds of off time. EA was performed at a clinical practice by a therapist with 10 years experience. The intensity of the EA was increased until the subject felt simulation and a little muscular contraction and was then maintained<sup>19</sup>).

For the skin measurement, JANUS (PSI Co., Ltd., Korea) was used. After the face was fixed at a certain position and external light sources were blocked, the facial skin conditions under irradiation by white light, polarized light and UV light were captured with a Canon DSLR camera with 10-million pixel resolution. For the measurement of pigmentation and skin tone, the measurement areas were set and measured ratios of each variable. To minimize the measurement errors, the same rater performed measurements from the beginning to the end in similar indoor environments (room temperature 20–21 °C and humidity 50–60%).

All data were coded and analyzed using the statistical analysis program SPSS (ver.18). To determine the post-intervention changes in pigmentation and skin tone in each group, a test of normality was conducted. If subjects passed the test, a paired samples t-test was conducted; otherwise, the Wilcoxon rank-sum test was performed. To determine the inter-group differences in pigmentation and skin tone, one-way ANOVA was used when the data satisfied normality; otherwise, the significance of differences was verified by the Kruskal-Wallis test. Significance was accepted for values of  $p < 0.05$ .

## RESULTS

The LLLT group showed no significant changes in post-intervention pigmentation ( $p > 0.05$ ). The EA group showed significant decreases in pigmentation in the left and right eye rims ( $p < 0.05$ ), as well as in left the cheek ( $p < 0.05$ ). The RF group showed significant decreases in pigmentation under the left eye ( $p < 0.05$ ), as well as in the left and right eye rims and the left cheek ( $p < 0.05$ ). The inter-group differences in the pigmentation changes were significant for the nose and left eye rim ( $p < 0.05$ ) (Table 2).

The LLLT group showed significant increases in skin tone in the forehead and both eye rims post intervention. ( $p < 0.05$ ). The EA group did not show any significant changes in skin tone ( $p < 0.05$ ). The RF group showed significant increases in skin tone under the left and right under eyes ( $p < 0.05$ ). The inter-group differences in the skin tone changes were insignificant ( $p > 0.05$ ) (Table 3).

## DISCUSSION

Aging refers to the physiological phenomenon in which structural and functional changes naturally appear in entities over time. In particular, human skin is an organ that shows clear changes with age. Skin aging can be classified into two categories: intrinsic aging caused by genetic programming and aging caused by external environmental conditions, e.g. exposure to UV rays, wind, heat, and tobacco<sup>3, 25</sup>). The categories of skin aging appear in various forms depending on the region and

**Table 1.** General characteristics

Variables	LLLT (n=10)	EA (n=10)	RF (n=10)
Age (yrs)	42.8 ± 4.9	43.4 ± 7.1	42.9 ± 3.7
Height (cm)	163.0 ± 7.9	158.0 ± 4.3	159.8 ± 4.3
Weight (kg)	56.7 ± 7.5	58.8 ± 7.2	52.4 ± 6.1

Values are shown as the mean ± SD. LLLT: low-level laser therapy group, RF: radiofrequency group, EA: electroacupuncture group

**Table 2.** Comparison of the intra-group and inter-group changes in pigmentation among the LLLT, EA, and RF groups

Pigmentation	Intervention	Pre	Post
<sup>a</sup> Forehead	LLLT	12.8 ± 7.0	12.9 ± 7.1
	EA	16.2 ± 5.3	15.3 ± 5.4
	RF	12.9 ± 7.6	13.3 ± 7.3
<sup>b</sup> Nose <sup>1,3&lt;2</sup>	LLLT	19.2 ± 8.0	18.7 ± 7.5
	EA	23.8 ± 7.1	23.0 ± 6.8
	RF	20.1 ± 9.6	20.5 ± 9.4
<sup>a</sup> Under eyes	Right	LLLT	26.2 ± 7.5
	EA	24.4 ± 7.0	23.3 ± 5.7
	RF	23.3 ± 10.5	21.8 ± 9.3
Left	LLLT	24.4 ± 7.7	22.6 ± 7.1
	EA	27.8 ± 8.3	25.1 ± 8.0
	RF*	23.6 ± 12.7	22.1 ± 12.7
<sup>a</sup> Eye rims	Right	LLLT	26.1 ± 8.7
	EA*	25.8 ± 7.7	22.1 ± 7.6
	RF*	24.8 ± 8.9	23.4 ± 9.1
Left <sup>2,3&lt;1</sup>	LLLT	26.0 ± 10.3	25.9 ± 9.2
	EA*	26.2 ± 6.4	22.2 ± 6.3
	RF*	27.5 ± 5.6	24.5 ± 6.3
<sup>a</sup> Cheeks	Right	LLLT	28.5 ± 10.6
	EA	26.6 ± 6.6	25.6 ± 6.1
	RF	25.7 ± 10.7	27.4 ± 10.8
Left	LLLT	26.7 ± 10.7	26.7 ± 10.2
	EA*	27.9 ± 8.3	25.7 ± 8.1
	RF*	27.2 ± 11.3	25.8 ± 10.7

Values are shown as the mean ± SD. \*Significant difference between (p<0.05) the pre- and post-tests within each group: <sup>a</sup>Paired samples t-test, <sup>b</sup>Wilcoxon rank-sum test. LLLT: low-level laser therapy, EA: electroacupuncture, RF: radiofrequency, 1: LLLT, 2: EA, 3: RF

psychological stress. To overcome this process, various efforts to delay the progress of skin aging are being made worldwide, and anti-aging-related markets are growing rapidly<sup>1)</sup>. In this study, the effects of LLLT, EA, and RF on the pigmentation and skin tone of adult women's faces were investigated.

Lee et al.<sup>23)</sup> found that the melanin level significantly decreased after the irradiation by blue or red LED light (p<0.05). Weiss et al.<sup>12)</sup> also found that erythema and pigmentation decreased in 90% of subjects. In their study, however, even though the values decreased, the differences were not significant. In an EA experiment with diabetic mice by Zhai et al.<sup>26)</sup>, both the erythema index and melanin index of the back skin decreased significantly. In a study by Budamakuntla et al.<sup>27)</sup>, the Melasma Area Severity Index (MASI) significantly decreased after microneedling, which was identical to the finding of this study.

Kim et al.<sup>28)</sup> reported that after the application of fractional RF, the melanin index and erythema index improved significantly. In the present study, pigmentation significantly decreased under the left eye, and in the right eye rim, the left eye rim, and the right cheek. Budamakuntla et al.<sup>27)</sup> which compared a Tranexamic acid microinjection group and a Tranexamic acid with microneedling group, and found the MASI of the microneedling group significantly decreased from 9.11 ± 4.09 to 5.06 ± 2.14 post-treatment (p<0.001), but the intergroup differences were not significant. Choi et al.<sup>24)</sup> compared RF and ultrasound

**Table 3.** Comparison of the intra-group and inter-group changes in skin tone among the LLLT, EA, and RF groups

Skin tone	Intervention	Pre	Post
<sup>a</sup> Forehead	LLLT*	57.2 ± 2.6	60.2 ± 2.0*
	EA	55.9 ± 3.0	55.9 ± 3.2
	RF	56.9 ± 3.6	55.6 ± 3.8
<sup>b</sup> Nose	LLLT	52.8 ± 2.8	52.7 ± 2.5
	EA	51.8 ± 2.0	51.4 ± 2.9
	RF	52.6 ± 3.3	55.6 ± 3.8
<sup>a</sup> Under eyes	LLLT	46.2 ± 3.8	47.1 ± 3.9
	Right EA	47.8 ± 2.8	47.9 ± 3.1
	RF*	47.0 ± 3.0	48.3 ± 3.9
Left	LLLT	47.2 ± 3.8	48.1 ± 3.6
	EA	48.3 ± 3.0	48.4 ± 3.4
	RF*	47.6 ± 3.2	49.0 ± 3.5
<sup>a</sup> Eye rims	LLLT*	48.7 ± 5.2	51.1 ± 5.3
	Right EA	49.5 ± 3.7	50.1 ± 3.9
	RF	50.8 ± 3.3	51.8 ± 3.5
Left	LLLT*	49.9 ± 4.6	51.5 ± 4.9
	EA	50.2 ± 3.6	50.4 ± 4.1
	RF	50.6 ± 3.7	51.7 ± 4.0
<sup>a</sup> Cheeks	LLLT	50.0 ± 3.6	50.2 ± 3.2
	Right EA	49.7 ± 2.2	48.9 ± 3.5
	RF	50.0 ± 3.3	50.5 ± 4.1
Left	LLLT	51.7 ± 3.9	51.8 ± 3.9
	EA	50.70 ± 2.7	50.2 ± 3.5
	RF	51.3 ± 3.5	51.6 ± 4.03

Values are shown as the mean ± SD. \*Significant difference between (p<0.05) the pre- and post-tests within each group: <sup>a</sup>Paired samples t-test, <sup>b</sup>Wilcoxon rank-sum test. LLLT: low-level laser therapy, EA: electroacupuncture, RF: radiofrequency, 1: LLLT, 2: EA, 3: RF

and reported, the RF group showed a significant reduction in pigmentation compared to the ultrasound group. In a study by Park et al.<sup>29)</sup>, the pigmentation of subjects who received microneedle therapy system (MTS) treatment significantly decreased compared to those receiving RF. In the present study, the EA group showed better effects in terms of nose pigmentation, and the EA and RF groups showed better results the left eye rim than the LLLT group.

Lee et al. reported that 14 out of 24 patients experienced an increase in skin tone after being irradiated by red LED light<sup>23)</sup>. Similarly, in the present study, the skin tone of the LLLT group significantly increased in the forehead, the right eye rim, and the left eye rim.

Fitzpatrick et al.<sup>20)</sup> reported improved skin tone after the application of RF. In the present study, the RF group showed significant increases in skin tone under the left and right eyes. According to Tobin and Paus, skin tone is generated by a mixture of melanin, hemoglobin, and carotene, with melanin having the greatest effect. In the present study, the skin tone improved as a result of reduced pigmentation<sup>30)</sup>.

Barrett<sup>19)</sup> also reported that skin tone improved after the application of EA, and Fabbrocini et al.<sup>31)</sup> reported that skin tone significantly increased in 17.4% of a group who received skin needling and depigmenting serum treatment and in 11.2% of a group who received depigmenting serum treatment only. In the present study, the EA group did not show significant changes in skin tone post intervention. The reason for this seems to be the differences between previous studies and the present study in terms of the electrical variables of the EA and in the application of serum, which can affect skin tone. Therefore, future studies need to take this into consideration.

This study had a few limitations. First, the number of subjects was small and only included adult women between 30 and 55 years of age. Therefore, the findings of this study cannot be generalized. Second, this study was conducted for a short period of only six weeks and the long-term effects were not evaluated. In the future, adult women of a broader age group should be studied, and long-term effects of more than six months should be verified.

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