Effect of 8 mW 525 nm LEDs Light Irradiation on the Defect Reduction in the Skin Wound of SD-rat

Min-Woo Cheon[a]
Department of Medicine, Chosun University,
375 Seosuk-dong, Dong-gu, Gwangju 501-759, Korea

[a]E-mail : ccuccu7@lycos.co.kr

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The purpose of this study is to develop the Photodynamic Therapy Equipment for medical treatment. We developed the equipment which was helpful in palpating wound healing by using 525 nm LEDs. The equipment was assembled with a micro-controller and green color LEDs, and designed to enable us to control light irradiation time, intensity and so on. In this study, the designed device was used to find out how 525 nm LEDs light affected the skin wound of SD-Rat(Sprague-Dawley Rat). We divided the participants into two groups; irradiation group which was irradiated one hour a day for 9 consecutive days, and none irradiation group. The results showed that the study group had lower incidence of inflammation and faster recovery, compared with the control group.

Keywords : Light emitting diode, Low level light therapy, Wound healing, Sprague-dawley rat

1. INTRODUCTION

Generally, skin wound healing has gone through inflammatory phase, proliferative phase and remodeling phase[1] and at this time a variety of internal or external causes including medicines, vitamins, radiotherapy, and collagen synthesis affect the wound healing process[2,3].

Light could be divided into three categories; ultraviolet, visible light, and infrared depending on wavelength. The treatment method to use these lights in curing diseases or symptoms is expressed in "Phototherapy" or "Light therapy." Light therapy, based on thermal effects, has been developed over a long time in mankind history. In particular, low level laser therapy, which is one of the major treatments in medical field, activates cell functions by making organic cells strongly excited when certain wavelength of photons agree with cell peculiar wavelength, and this laser has been effectively applied to wound healing[4] and inflammation treatment[5]. Even though light therapy is recognized to be pretty effective, taking the therapy for more than resonable time poses a high risk triggering skin aging[6]. Especially, when skin is exposed to UVA and UVB, skin bio-synthesis efficiency gets low enough to cause skin damage or skin aging because 70 % of inner skin is made of collagen[7].

This study examined the effects of 8 mW 525 nm LEDs irradiation on skin wound healing in SD-Rat.

2. DEVELOPMENT OF LIGHT IRRADIATION SYSTEM

The light irradiation system used in the present study is LED light irradiation device which has been developed for use in wound healing or biological experiments in a various ways and it is designed to ensure 4 LED light modules at maximum may be controlled simultaneously or individually[8,9]. Figure 1 shows a schematic diagram of system.

The 4 channel light irradiation system is designed to enable users to selectively control the light curing time(Timer), light power(mW/cm^2), and reservations for each channel. The micro controller used in this equipment is configured to ensure to have a general control over LCD Display that shows the real time function or module On/Off, output regulating of LED light module through the 53 I/O lines by receiving control signals from ATmega128. LED driver, one of the key parts in this system, used TLC5941 to regulate the light power and used two TLC5941 for every output channel of the system to supply many LEDs with the rated current.

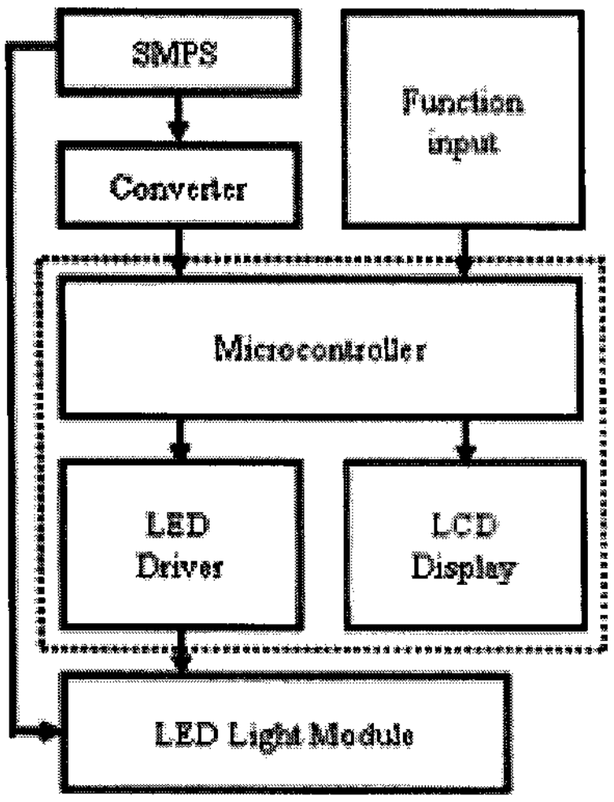


Fig. 1. Schematic diagram of system.

2.1 Display & switch

The display shows On/Off state of light radiation unit or LED Driver, with 16x4 column Text LCD, and it is designed to effectively use micro controller specific I/O port in Serial interface method. And the irradiation unit was structured so that the user may input control signals with switch in order to work a specific function, and especially, it was designed to ensure that 4 LED drivers may perform functions for light radiation time, intensity.

2.2 Micro-controller

For the control part, the most important component in light radiation unit, CMOS 8 bit Micro-controller, ATmega128 made by ATmeal Company was employed. ATmega128 is equipped with 7 independent channels through PORT A ~ G and I/O line available for 53 programs, and its controller plays a role in controlling On/Off state for LCD display, timer, LED Driver.

2.3 LED driver

As LED is increasingly used, diverse driving-type IC have been developed and for the light radiator unit, TLC5941 was used to control many LEDs simultaneously. The used TLC5941 plays a role in controlling 96 LEDs at a time while driving at 3.0 ~ 5.5 V and enduring a maximum constant current of 90 mA. In addition, it consists of 16 output channels of constant current ranging from 0 to 15, which allows users to regulate the respective output currents and brightness deviations of LED connected to each channel, and in result, it is characterized to obtain equal output for every channel. It divided 64 step sink(Dot correction) of TLC5941 into 4 steps to make it possible to regulate each output and set up a maximum of 64 step to produce the maximum output at step 4.

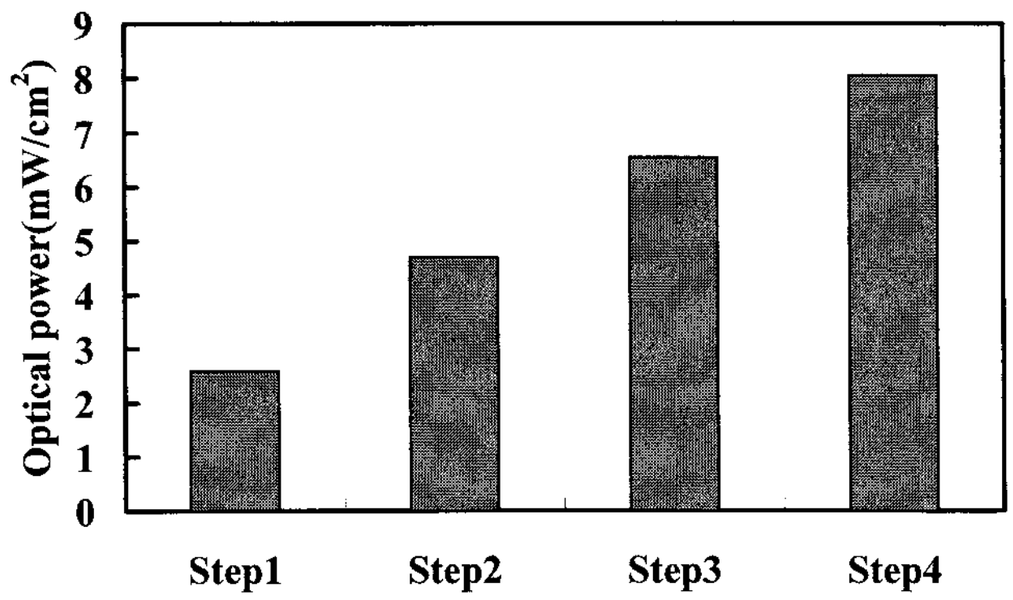


Fig. 2. Optical power on step variations.

Figure 2 shows changes in optical power of 525 nm optical modules, used in the test, depending on step variations and in result, it was found that optical power could be controlled at each step. The equipment for measurement in this study is optical power meter which is manufactured by ADVANTEST Corp. and available to measure the values of 1 nW ~ 50 mW at 360 ~ 1100 nm wavelength level by using 10 × 10 mm Si director.

3. RESULTS AND DISCUSSION

The animals used for this experiment were male Sprague-Dawley rats(SD Rat) which weighed 250 ~ 280 g. The light irradiation was applied to the rat for one hour per day for 9 consecutive days 24 hours after rats had been purposively wounded. Table 1 shows the experimental conditions for rats.

Table 1. The experimental conditions.

	Light exposed rat
Wavelength	525 nm
Light intensity	8 mW/cm^2
Defect size	1 cm^2
Irradiation time	60 min/day for 9 days
Temperature	24 ~ 26 ℃

Our independently developed light curing device was employed to investigate the effects of the irradiation of 525 nm LED on the wound healing of the rat. And the rats for the test were divided into four groups, one group of which consisted of one rat who is subject to light irradiation and the other not irradiation.

Figure 3 shows an actual image which the light irradiation of 525 nm LED was applied to each test group.

Some observations were made to examine whether irradiated rats and non-irradiated rates were recovered from their skin injuries and there was no difference found with the naked eyes between the two groups. Therefore, to get the more exact result than the visible one, regarding the skin remodeling of wounded lesion, an examination of skin tissue was performed. It was found that a human skin has responses like inflammation and fluid secretion occurred right after skin injury happened and these reactions keep going on until the newly created granulation tissues remodel completely the wounded lesion. Figure 4 shows a graph that expresses the result of the remodeling of newly created skin granulation tissues through microscopical examination of sliced tissues from the light irradiation group and non-irradiation one. It was found that the light irradiation group underwent the wound healing earlier than the non-irradiation group among all four groups.

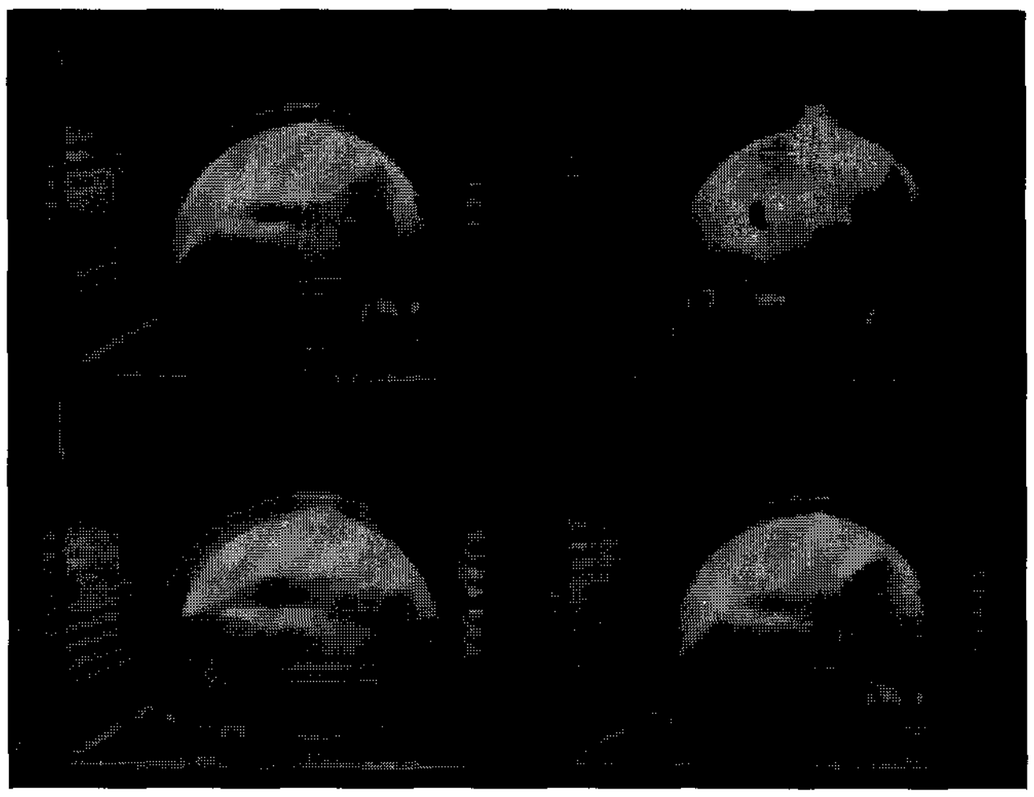
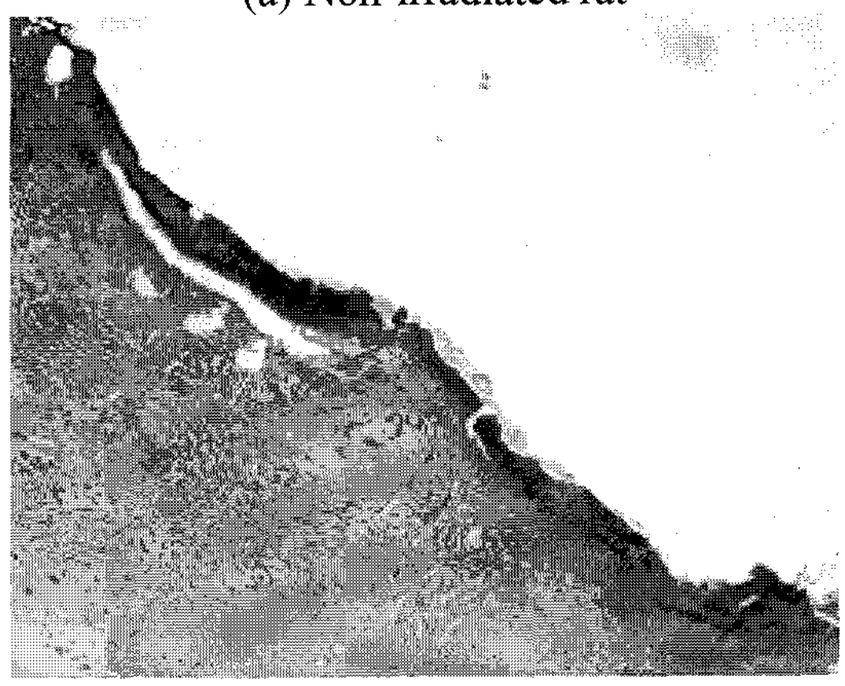


Fig. 3. Image of 8 mW 525 nm LEDs light irradiation.

Fig. 4. Wound healing result for each group.

Figure 5 shows the sliced tissue image of group-4 which has the biggest difference in the wound healing results. The microscopical examination shows that non-healed lesion of 525 nm LED non-irradiated rat is 3,605 μm in a straight line, which means the injury part gets smaller about 64 %, while the 525 nm LED irradiated rat had more than 89 % in skin regeneration rate, with the distance of absence of skin about 1,131 μm.

(a) Non-irradiated rat



(b) Irradiated rat

Fig. 5. Microscopical image of SD-rat skin section.

4. CONCLUSION

The study has carried out in-vivo experiment by employing our own developed LED irradiation system to investigate the effects of the 8 mW 525 nm LEDs irradiation on the wound healing as a preliminary study aimed at the application of 8 mW 525 nm LED light to wound healing of human skin injury.

The whole skin layers of SD rat on the back part were cut out in 1 cm diameter and given light irradiation for 9 days and the observations found that the light irradiated rat showed earlier wound healing than non-irradiated rat during the test period.

REFERENCES

[1] E. M. Vinck, B. J. Cagnie, M. J. Cornelissen, H. A. Declercq, and D. C. Cambier, "Increased fibroblast proliferation induced by light emitting diode and low power laser irradiation", Laser, Med. Sci., Vol. 18, p. 95, 2003.

[2] J. Imanishi, K. Kamiyama, I. Iguchi, M. Kita, C, Sotozono, and S. Kinoshita, "Growth factors: importance in wound healing and maintenance of transparency of the cornea", Progress in Rentnal and Eye Research, Vol. 19, No. 1, p. 113, 2000.

[3] A. R. Medrado, L. S. Puglese, S. R. Resi, and Z. A. Andrade, "Influence of low level laser therapy on wound healing and its biological action upon myofibroblases", Laser. Surg. Med., Vol. 32, p. 239, 2003.

[4] M. T. Wongriley, X. Bai, E. Buchmann, and H. T. Whelan, "Light-emitting diode treatment reverse the effect of TTX on cytochrome oxidase in neurons", Neuroreport., Vol. 12, p. 3033, 2001.

[5] H. T. Whelan, R. L. J. Smiths, E. V. Buchman, N. T. Whelan, S. G. Turner, D. A. Margolis, V. Cevenini, H. Stinson, R. Ignatius, T. Martin, J. Cwiklinski, A. F. Philippi, W. R. Graf, B. G. L. Hodgson, M. Kane, and G. Chen, "Effect of NASA light-emitting diode irradiation on wound healing", J. Clin Laser Med Surg., Vol. 19, p. 305, 2001.

[6] G. J. Fisher, S. Kang, J. Varani, Z. Bata-Csorgo, Y. Wan, S. Datta, and J. J. Voorhees, "Mechanisms of photoaging and chronological skin aging", Arch. Dermatol., Vol. 138, p. 1462, 2002.

[7] M. H. Shin, G. E. Rhie, C. H. Park, K. H. Kim, K. H. Cho, H. C. Eun, and J. H. Chung, "Modulation of collagen metabolism by the topical application of dehydroepiandrosterone to human skin", J. Invest. Dermatol., Vol. 124, p. 315, 2005.

[8] M. W. Cheon, S. H. Kim, K. Y. So, Y. L. Moon, S. P. Mun, Y. P. Park, H. S. Lee, and T. G. Kim, "4-channel light medical therapy apparatus for external injury cure", J. of KIEEME(in Korean), Vol. 20, No. 8, p. 731, 2007.

[9] M. W. Cheon, S. H. Kim, Y. P. Park, T. G. Kim, and S. M. Yu, "The effect of LED light irradiation on skin injury cure of rat", J. of KIEEME(in Korean), Vol. 20, No. 12, p. 1087, 2007.