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A practical comparison of Copper Bromide Laser for the treatment of vascular lesions

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Abstract— **The recent rapid growth in demand for aesthetic non-invasive laser treatments such as unwanted skin rejuvenation, removal of age-related vascular blemishes has led to a boom in the medical devices to treat these conditions. Among diverse laser for skin treatment, copper bromide laser is a very effective, safe, and well tolerated treatment for facial telangiectasia at various energy levels and the most important thing of the copper bromide laser device is that the stability of the energy. However there is no evidence about effective copper bromide laser's energy level for the treatment of vascular lesions. We compared energy stability and treatment performance between two energy levels in 2W and 8W which commonly use in laser treatment for the vascular lesions. 8W copper bromide laser was more stable compared than 2W copper bromide laser. Also, 8W copper bromide laser was effectively superior to 2W copper bromide laser in treatment of vascular legion. Consequently, 8W copper bromide laser treatment for vascular lesion might be more suitable than 2W copper bromide laser.**

I. INTRODUCTION

The yellow laser is known to affect epidermis melanin, vessel structures of degenerated corium, and epidermal VEGF while showing antiangiogenic effects which are thought to aid freckle treatment. According to a recent clinical research, the manifestation of VEGF within keratogenesis cells significantly diminished after copper bromide yellow laser (578nm) treatment, as the yellow laser affects the formation of VEGF and corium vessels within keratogenesis cells, while inflammation vehicles directly and indirectly affect the formation of melanin, effectively treating freckles.

Copper bromide laser is a very effective, safe, and well tolerated treatment for facial telangiectasia at various energy levels. (1) Also, the potential application of an antiangiogenetic copper bromide laser for the treatment of melasma specially accompanied by pronounced telangiectasia in Asian skin is a possible treatment option. (2) But, the copper bromide laser is less suited to treating very small vessel lesions such as diffuse erythema, and conversely very large vessels as well as those of the nasal alae. (3)

Generally, copper bromide laser was an effective tool in the treatment of certain cutaneous vascular lesions. (4) And a 578 nm copper bromide (CuBr) yellow light laser produces excellent results in eradicating red telangiectases of the lower extremities that are less than 2 mm in diameter. (5)

However, there are various energy levels for laser therapies. Argon laser (0.5 watt, 5 to 7 minutes exposure) fused specimens had no evidence of suture material at the anastomotic line, and healing consisted of a bond between artery and vein wall tissues. (6) And at 1 W, the tissue was desiccated and the welds disrupted when exposed to blood flow, but at 0.50 W, the fusion failed after only minimal exposure to the laser energy because of tissue drying and retraction with temperatures. (7) Nd:YAG laser 1320 nm (2 Watt, 20 seconds and 3 Watt, 8 seconds) via an applicator with radial symmetrical light distribution occlusion of recto urogenital fistulae will be easier to achieve since fistula occlusion. (8) Carbonization of the metallic tip and adherence of atherosclerotic debris with secondary vessel tearing which pulses of 6 watts were delivered to the laser probe were potential adverse effects of the laser probe. (9) Laser with energy power of 8-10 watt irradiation a connective tissue scar was formed substituting the defect in the vascular wall and covered from the lumen side with a thin continuous layer of endothelium. (10) Radial heating by the hot tip probe using argon laser with power of 10 watts can cause thermal perforation. Blood flow or saline infusion modifies nontarget heating and may offer significant protection to the vasculature. (11) Patients who underwent 15 watt laser angioplasty alone, no noticeable improvement in distal blood flow were demonstrated by doppler velocimetry, and reocclusion occurred either soon afterwards or later. (12) The Coronary laser balloon angioplasty system which consists of a 50 watt continuous wave laser has been shown to be effective in the management of acute failure of pressure to thermally weld tissue during coronary angioplasty. (13)

However there is no evidence about effective copper bromide laser's energy level for the treatment of vascular lesions. Therefore, the purpose of this study was to discover optimal energy level that commonly use in copper bromide laser treatment for the vascular lesions.

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II. METHODS

Copper bromide laser equipment

Although an existing laser treatment system with Nd:YAG and CO_2 laser were widely used for skin treatment procedure due to their universality, currently available copper bromide laser system was developed by Bison medical Co., Ltd for the treatment of vascular lesions.

This copper bromide laser equipment consist of optical fiber delivery system and air cooling system and laser tube with 1,100 mm size, which has two wavelength of 511nm and 578 nm with maximum output power of 12W as Figure 1.

Figure 1. Copper bromide laser equipment

Copper bromide laser configuration

This copper bromide laser system consists of laser tube, high power supplier, main control board, handpiece, fiber, foot switch, LCD module, filter wheel, motor wheel(ON/OFF wheel) and other components as figure 2. Additionally there are control part and sensor part which modulate the irradiate laser, also filter part use the two different wave length of copper bromide laser selectively.

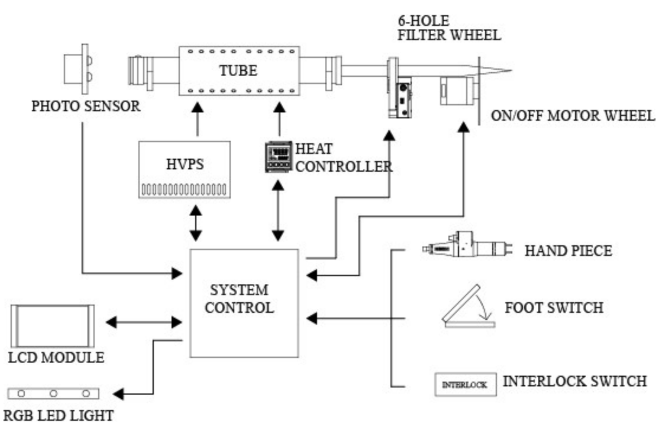


Figure 2. Copper bromide laser configuration

Laser tube

There is a need to optimized laser tube length for the treatment of vascular lesion. After a lot of laboratory tests, we found the optimal laser tube length and that was from 1,000mm to 1,200 mm. If the laser tube length was under the 1,000mm, copper bromide laser could not reach the lower epidermis legion and that deteriorate the skin treatment effects. Meanwhile, if the laser tube length was over the 1,200mm, copper bromide laser output power would over the 12W and we could not adequate laser output level for the treatment of vascular legion.

Therefore, we developed optimal laser tube for the treatment of vascular legions as figure 3.

Figure 3. Copper bromide laser tube

Filter and motor(ON/OFF) wheel

Since copper bromide laser system needs continuous supply of high voltage electricity to the glass tube, it requires the continuous discharging. In other words, there is a need for laser output modulation outside the glass tube, so we developed motor filter to modulate the copper bromide laser energy output as figure 4. Our developed filter wheel consists of six filter hole which mixed laser with different wavelength. As seen in below figure 4, RPM will be checked using electric motors to check the timing of laser beam so that 8-mouth On/Off wheel may work as 511nm and 578nm penetrate.

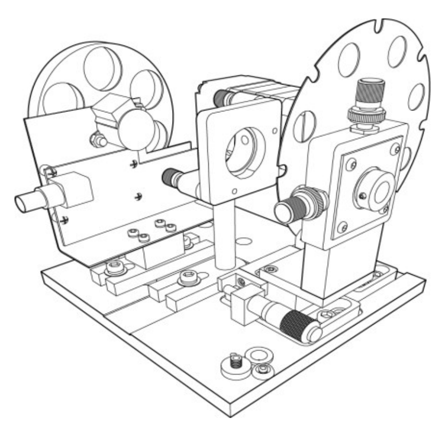


Figure 4. Motor filter of copper bromide laser system

Optical system of copper bromide laser

Optical system of copper bromide laser consists of main body, delivery system and handpiece. In the main body, copper bromide laser focused by focusing lens and beam shutter. In the delivery system, laser transmitted to the handpiece by optical fiber. In the handpiece, copper bromide laser irradiated to the target by beam collimator as figure 5.

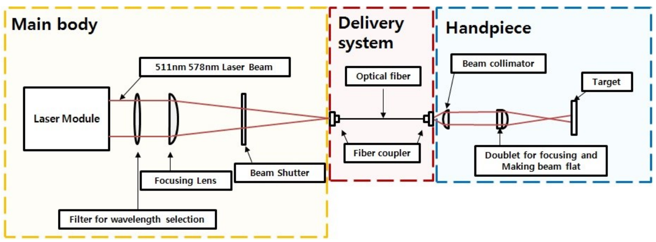


Figure 5. Optical system of copper bromide laser

Algorithm for power of copper bromide laser

Power output of laser tube is constantly changing due to temperature variation of laser tube. However, stability of power output in the laser treatment is most important thing for the stability of treatment effects. For the solution of this problem, we calculated optimal tube temperature using proportional integral differential (PID) algorithm as follows.

$$G_C(s) = K_1 + \frac{K_2}{s} + K_3 s = \frac{K_1 s + K_2 + K_3 s^2}{s}$$

K_1, K_2, K_3 : Gain Value

We developed the PID modulator using this algorithm for the control of laser tube temperature by measuring of laser's output power which detected by photodiode sensor as figure 6. Power output of laser from irradiated from the laser tube was measured when that would reached photodiode sensor through beam splitter and ND filter. And then photodiode sensor transmitted the temperature results to the main controller. If power output of copper bromide laser was too low, they rise the tube temperature by operating of heat controller. Using this method, we detected the variation of laser power output by results monitoring of photodiode sensor, and it could maintain the laser's output constantly by modulation of tube temperature.

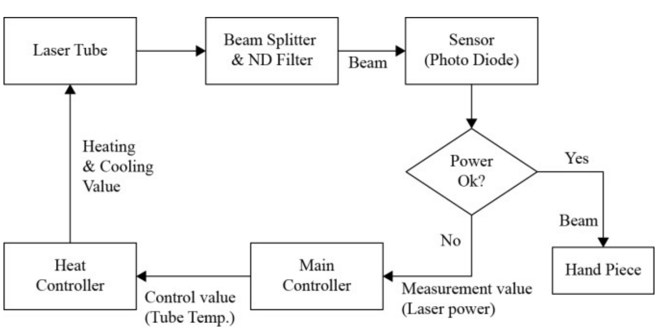


Figure 6. Diagram for compensation of copper bromide laser's power

Experiment

We tested the energy stability in copper bromide laser system in 2W and 8W respectively. Its conditioning time was 5.5 hours and we measured energy output level in every 5 minute. Total experiment time of copper bromide laser system was 56 hours.

In order to the evaluation of copper bromide laser for the treatment of vascular legions, Korean rabbit weighing 2.9 kg was used and laser was irradiated to the vascular lesion of right ear from the same rabbit during 1.6 second respectively.

Statistical analysis

For the evaluation of the laser energy output stability, normal distribution with Sahpiro-Wilk test was used. Considering the analysis of variance (ANOVA), the Levene's test was also performed to evaluate the ANOVA result.

Statistical software IBM SPSS statistics 20 was used for the analysis.

III. RESULTS

Energy output stability of copper bromide laser

The data (laser output energy) concerning the normal distribution and homogeneity of variance are shown in Table 1. Total 606 data from the copper bromide laser output energy was analyzed in 2W and 8W respectively. Both energy level were not satisfied with the requirements of normal distribution but data distribution from 8W energy level was close with normal distribution($p=0.01$) than 2W energy level and their p value were($p<0.001$). Also their data variance from copper bromide energy output level were significant different ($P<0.001$).

TABLE I. TEST RESULT FOR THE NORMAL DISTRIBUTION AND HOMOGENEITY OF VARIANCE

Shapiro-Wilk test			
Power	***Statistic***	***df***	***P value***
2W	0.945	606	<0.001
8W	0.994	606	0.010
Levene test			
Statistic	***df1***	***df2***	***P value***
237.8	1	1210	<0.001

Figure 7 shows the QQ plot on the normal distribution of copper bromide laser's power output. 8W laser's distribution of power output was more close to normal distribution compare than the 2W laser's one.

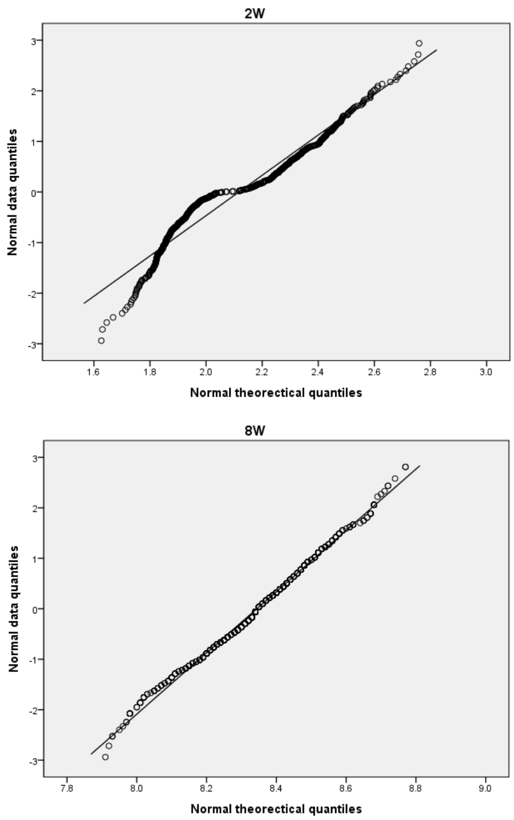
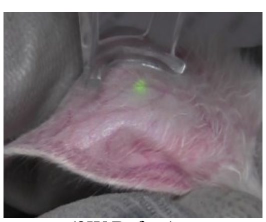


Figure 7. QQ plots of copper bromide laser's power output

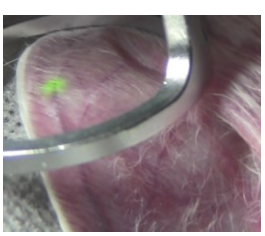
Treatment of vascular lesion

After the irradiation of copper bromide laser which have different energy output level in 2W and 8W, there was a different change in vascular legion of rabbit. Under the same irradiation condition except energy output level, only 8W copper bromide laser could ablated the vascular legion of the rabbit's ear. On the other hand, there was not significant change in irradiated rabbit's ear with copper bromide laser in 2W as figure 6.

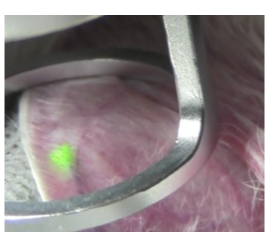


(2W Before)

(2W After)



(8W before)



(8W After)

Figure 8. Irradiated vascular legion with Copper bromide laser

IV. CONCLUSION

8W copper bromide laser was more stable compared than 2W copper bromide laser. Also, 8W copper bromide laser's treatment effect of vascular legion was more superior to the 2W copper bromide laser's one. Consequently, 8W copper bromide laser treatment for vascular lesion might be more suitable than 2W copper bromide laser.

Also, copper bromide laser can clarify skin tone through the "yellow toning treatment" of vessel lesion acne, rosacea, hemotelangiosis, freckles, liverspots, warts, etc. It can also be utilized in various ways to show corium collagen synthesis, photorejuvenation effects, etc. A single laser can provide various modes for convenient treatment, making it a useful tool at new hospitals.

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