EFFICACY OF LASER IRRADIATION ON THE AREA NEAR THE STELLATE GANGLION IS DOSE-DEPENDENT: A DOUBLE-BLIND CROSSOVER PLACEBO-CONTROLLED STUDY

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In the present study we evaluate the effects of laser irradiation on the area near the stellate ganglion on regional skin temperature and pain intensity in patients with postherpetic neuralgia. A double blind, crossover and placebo-controlled study was designed to deny the placebo effect of laser irradiation. Eight inpatients (male 6, female 2) receiving laser therapy for pain attenuation were enrolled in the study after institutional approval and informed consent. Each patient received three sessions of treatment on a separate day in a randomized fashion. Three minutes irradiation with a 150 mW laser (session 1), 3 minutes irradiation with a 60 mW laser (session 2), and 3 minutes placebo treatment without laser irradiation. Neither the patient nor the therapist was aware which session type was being applied until the end of the study. Regional skin temperature was evaluated by thermography of the forehead, and pain intensity was recorded using a visual analogue scale (VAS). Measurement were performed before treatment, immediately after (0 minutes) then 5, 10, 15, and 30 min after treatment. Regional skin temperature increased following both 150 mW and 60mW laser irradiation, whereas no changes were obtained by placebo treatment. VAS decreased following both 150 mW and 60 mW laser treatments, but no changes in VAS were obtained by placebo treatment. These changes in the temperature and VAS were further dependent on the energy density, i.e the dose. Results demonstrate that laser irradiation near the stellate ganglion produces effects similar to stellate ganglion block. Our results clearly indicate that they are not placebo effects but true effects of laser irradiation.

Key words: laser irradiation, stellate ganglion, postherpetic neuralgia, double blind, crossover, placebo-controlled study

Introduction

There are several clinical reports indicating that laser irradiation on the area near the stellate ganglion produces a similar effect to stellate ganglion block in the management of facial palsy,[1] allergic rhinitis[2,3] and neuropathic pain,[4-6] all of which are indications for stellate ganglion block. There has been no report on the efficacy of laser irradiation on the area near the stellate ganglion evaluated by a double blind placebo controlled study. Some still may claim that the vast majority of publications on laser-mediated pain relief are either empirical or anecdotal reports based on the author's clinical experiences.[7] The comparative lack of double blind, controlled and crossover studies has resulted in such claims. Accordingly in this study, we evaluated the effects of laser irradiation near the stellate ganglion on regional skin temperature and pain intensity in patients with postherpetic neuralgia by the double blind crossover placebo-controlled study.

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Methods

Eight inpatients (male 6, female 2) aged between 62 and 79 years old were enrolled in this study after institutional approval and informed consent. All patients had been treated at the inpatient clinic because of postherpetic neuralgia of the facial type on the first branch of the trigeminal nerve (4 patients of the right side and 4 for left), and received laser therapy.

Two GaAlAs semi-conductor lasers therapy systems were employed with a wave length of 830 nm and output powers of 60 mW and 150 mW (MLD-1002 and MLD-1003, respectively, Mochida, Tokyo, Japan). Probes of both systems are similar in size, shape and weight. These systems are classified under the ANSI classification as class IIIB lasers. Each patient received all of the following three treatment session types on a separate day in a randomized fashion. The types consisted of 3 min irradiation with a 150 mW laser (session 1), 3 min irradiation with a 60 mW laser (session 2), and 3 min of placebo treatment using the same probe as session 2 but without laser irradiation (session 3). Room temperature for the study was kept constant at 25 ± 1°C during the whole procedure. The patient was prescribed bed rest for 15 min before each session of treatment. An examiner handed a probe of the laser therapy system to a therapist through a thick curtain which separated the examiner from both the therapist and the patient. The probe was applied on the anterior aspect of the lateral process of the 7th cervical vertebrae by the therapist. The probe was applied with pressure in the contact method. Neither the patient nor the therapist was thus able to identify which treatment session type (1, 2 or 3) was applied for the specific study until the study was completed.

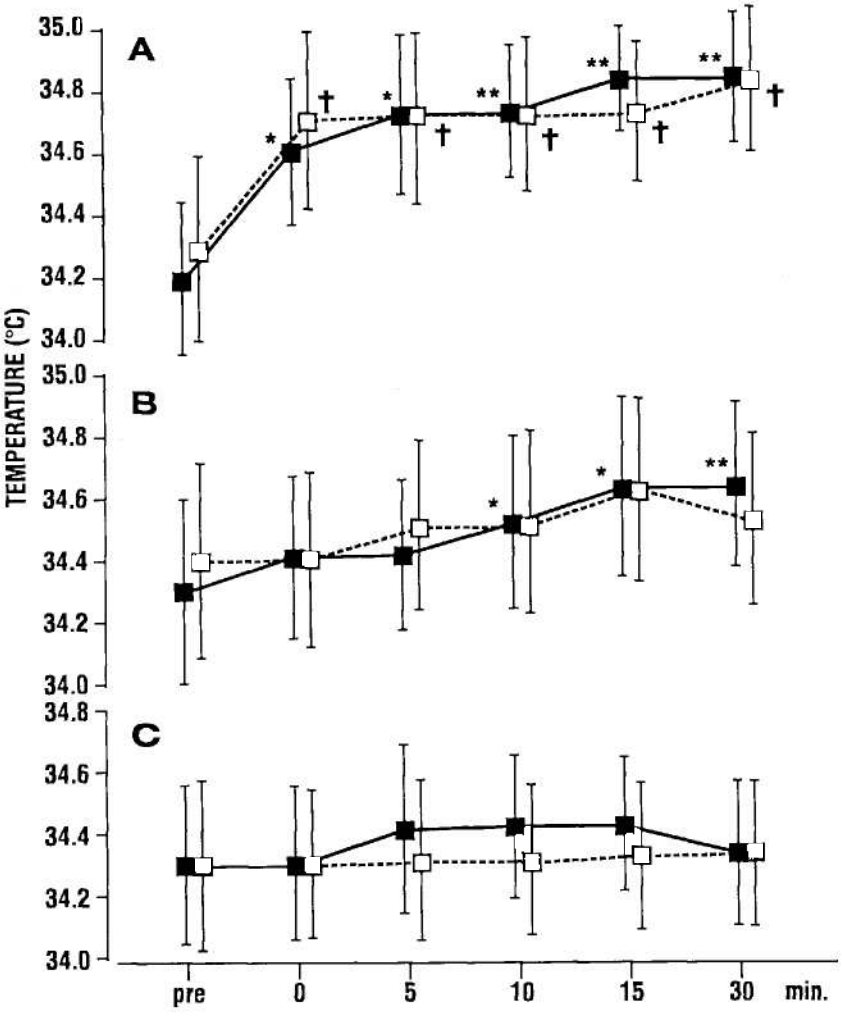

Fig. 1: Changes in forehead temperature following treatment with 150 mW, 60 mW and sham (placebo) laser.
A, 150 mW: B, 60 mW: and C, placebo treatment.
■: irradiation side (real or placebo treatment);□: contralateral unirradiated side. Bars indicate ± SEM.
*; significant difference ($p < .05$) vs pre-irradiation value on the irradiation side. **; significant difference ($p < .01$) vs pre-irradiation value on the irradiation side. †; significant difference ($p < .05$) vs pre-irradiation value on the non-irradiation side

Measurements of regional skin temperature and pain intensity were performed before each treatment, and served as the control. Measurements were repeated immediately after treatment (i.e. 0 min), then at 5, 10, 15, and 30 min after treatment. Thermograms of the face were obtained using a TH 3108 thermography system (NEC-Sanei, Tokyo, Japan). The mean temperature of the forehead area (area of 3 cm x 3 cm) of both the irradiated side and the contralateral unirradiated side was calculated by a computer (PC 98021, NEC) using a thermogram analysis program. An 11 point visual analogue scale (VAS) was used to evaluate pain intensity in each patient. Zero indicates no pain and 10 indicates maximum pain. The VAS was recorded by the examiner at the same points of the temperature measurements.

The values were expressed by mean ± SEM. The two-way analysis of variance (ANOVA), with Fishers's PLSD post hoc test was used for statistical analysis in each group. The repeated measure ANOVA with Fisher's PLSF post hoc test was used for statis-

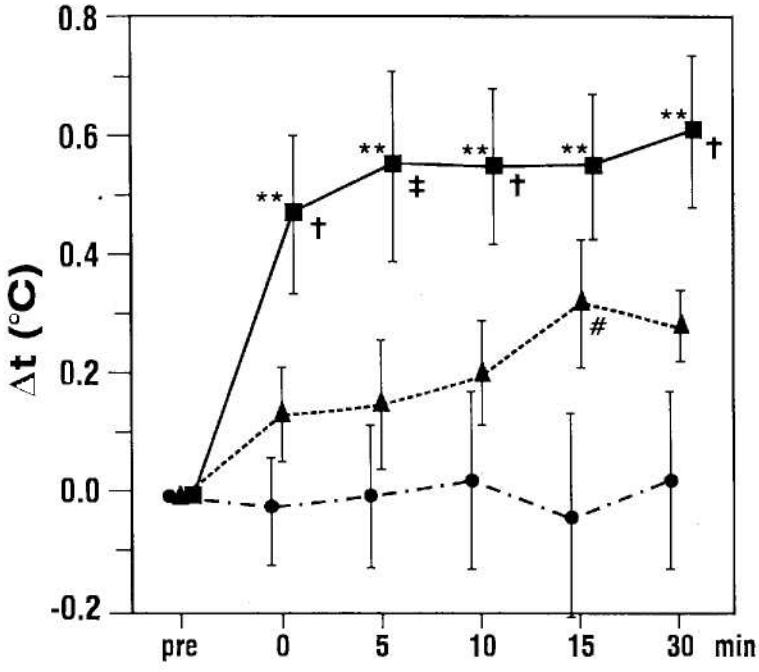

Fig. 2: Absolute temperature changes (Δ t) compared for the three treatment groups.
■: 150 mW, ▲: 60 mW, ●: placebo treatments. Bars indicate ± SEM.
**: significant difference ($p < .01$) 150 mW vs placebo. †: significant difference ($p < .05$) 150 mW vs 60 mW. ‡: significant difference ($p < .01$) 150 mW vs 60 mW.#: significant difference ($p < .05$) 60 mW vs placebo.

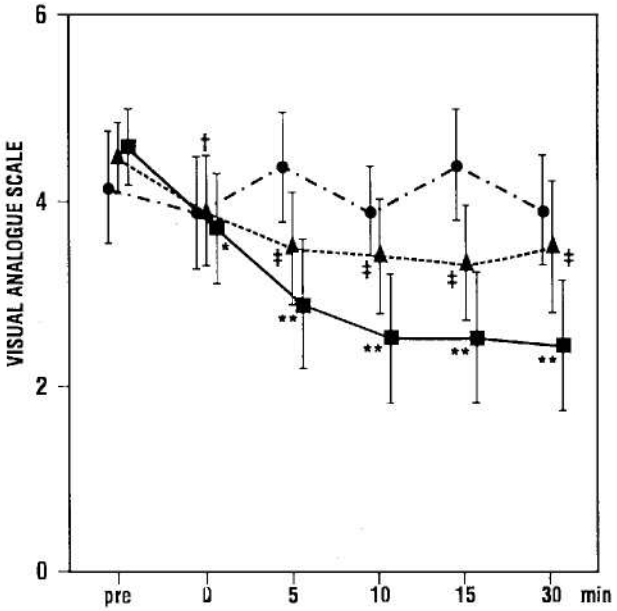

Fig. 3: Changes in VAS comparing treatment with 150 mW, 60 mW and placebo (sham irradiation).
■: 150 mW, ▲: 60 mW, ●: placebo treatments. Bars indicate ± SEM.
*; significant difference ($p < .05$) vs pre-irradiation value in 150 mW treatment group. **; significant difference ($p < .01$) vs pre-irradiation value in 150 mW treatment group. †;significant difference ($p < .05$) vs pre-irradiation value in 60 mW treatment group. ‡. Significant difference ($p < .01$) vs pre-irradiation value in 60 mW treatment group.

tical analysis between groups. A value of p of less than 0.05 was deemed statistically significant.

Results

Forehead temperature on the irradiation side by the 150 mW laser was significantly increased from 34.2 ± 0.2°C before treatment to 34.6 ± 0.2°C immediately after treatment. Then it was increased to 34.7 ± 0.2°C at 5 min, 34.7 ± 0.2°C at 10 min, 34.8 ± 0.2°C at 15 min and 34.8 ± 0.2°C at 30 min after treatment. Similar changes in forehead temperature on the contralateral unirradiated side were obtained by the 150 mW laser (Figure 1-A). Significant changes in the temperature on the irradiated side were obtained 10, 15 and 30 min after treatment with the 60 mW laser. No temperature increase was obtained on the unirradiated side with the 60 mW laser (Figure 1-B). The placebo treatment did not give a significant increase in forehead temperature either on the sham irradiated or the unirradiated sides (Figure 1-C).

The absolute temperature differences before and after treatment (Δt) for the 150 mW, 60 mW and placebo groups are shown in Figure 2. There were significant differences at all measurement points after treatment between the 150 mW and placebo groups, and between the 150 mW and 60 mW groups. There was a significant difference only at the 15 min point between the 60 mW and placebo groups.

Significant decreases in VAS were observed following 150 mW laser therapy from 4.6 ± 0.4 before treatment to 3.7 ± 0.6 immediately after treatment. It then decreased to 2.9 ± 0.7 at 5 min, 2.5 ± 0.7 at 10 min, 2.5 ± 0.7 at 15 min, and 2.4 ± 0.7 at 30 min after treatment. The VAS also demonstrated significant lowering of the pain score following treatment with the 60 mW laser, less, however, than those with the 150 mW laser (Figure 3). There were no changes in VAS scores following placebo treatment. Decreases in VAS at all measurement points between 150 mW and placebo groups, and between 150 mW and 60 mW groups were significant, whereas the difference at the 15 min point was only significant between the 60 mW and placebo groups (Figure 4).

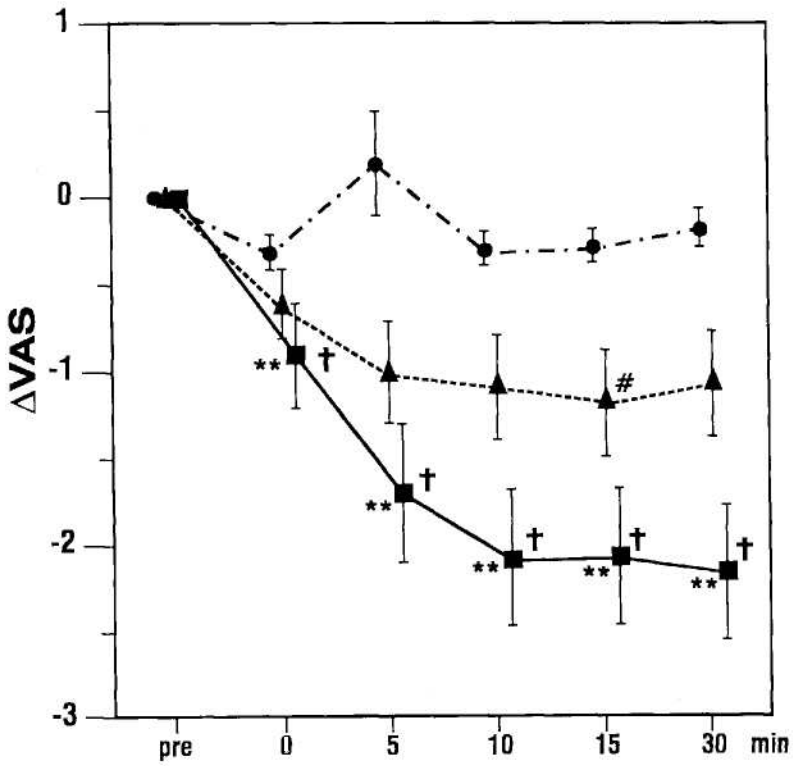

Fig. 4: Comparison of absolute VAS changes (ΔVAS) among the three treatment groups.
■: 150 mW, ▲: 60 mW, ●: placebo treatments. Bars indicate ± SEM. VAS; visual analogue scale.
** significant difference ($p < .01$) 150 mW vs placebo. †; significant difference ($p < .05$) 150 mW vs 60 mW. #: significant difference ($p < .05$) 60 mW vs placebo. VAS; visual analogue scale.

Discussion

Our results clearly demonstrated that laser irradiation on the area near the stellate ganglion by either 60 mW or 150 mW lasers was not a placebo effect but a true effect of laser. Placebo treatment did not produce any changes in regional skin temperature and VAS scores, whereas 60 mW and 150 mW lasers produced significant changes in the temperature and VAS scores. Our results also indicated that these effects were dependent on the energy density. The energy density or dose (expressed J/cm^2) is obtained by the product of the output power (in watts) and the irradiation time (in seconds) divided by the irradiation area (calculated using the formula πr^2). Accordingly the energy density obtained at one irradiation point (4 mm in diameter) in the contact method for 3 min with the 60 mW laser is 85.9 J/cm^2 whereas that of the 150 mW laser is 214.8 J/cm^2. Increases in the temperature and decrease in the VAS scores were more prominent with the 150 mW laser than with the 60 mW laser in our study. Based on the lower VAS scores, our findings suggest that 3 min irradiation with the 150 mW laser is more efficient than the same exposure time per point with the 60 mW laser. It also therefore suggests that 6 to 10 min irradiation time is necessary to get a satisfactory result using the 60 mW laser system because the dose (energy density) is dependent on the irradiation time.

Another important finding of our study was that laser irradiation on the area near the stellate ganglion reduced pain intensity with postherpetic neuralgia of the first branch of the trigeminal nerve. These results are in agreement with our previous reports [1, 2, 4 - 6] and studies by other investigators.[3] Our double blind crossover placebo-controlled study confirmed that laser irradiation near the stellate ganglion produced a similar effect to stellate ganglion block. Accordingly, laser irradiation near the stellate ganglion is indicated for various pain syndromes of the face, head, neck, upper extremity and upper chest which are otherwise suitable indications for stellate ganglion block.[8] Stellate ganglion block is also indicated for painless diseases including facial palsy and allergic rhinitis, because it produces an increase of regional blood flow. Therefore, laser irradiation near the stellate ganglion is also useful for these diseases.

Stellate ganglion block produces increases in regional blood flow by reduction of vascular tone accompanied with sympathetic blockade. Increases in regional skin temperature following stellate ganglion block are clinically evaluated by thermography.[9,10] Increases in forehead temperature by laser irradiation in our study indicated that laser irradiation near the stellate ganglion also reduced sympathetic control activity. There are several reports suggesting reduction in firing and conduction of peripheral nerves,[11,12] and the superior cervical sympathetic ganglion[13] in the rat. These animal studies suggest that laser irradiation near the stellate ganglion has surely some effect on the stellate ganglion in clinical settings.

Increases in forehead temperature were observed not only on the irradiation side but on the contralateral unirradiated side following therapy with the 150 mW laser but not with the 60 mW laser in this study. This means that laser irradiation might affect the stellate ganglion on the unirradiated side by scattering of the laser beam, if enough energy is applied. Another possibility is that laser irradiation affects the bilateral sympathetic nervous system through the ascending pathway. It was also reported that effects of laser irradiation are different among patients depending on sen-

sitivity to laser irradiation.[1,6] It is our clinical experience that some patients showed prominent temperature increases following treatment with the 60 mW laser, whereas only slight changes were obtained with 150 mW laser therapy inother patients. One particular therapist applied the probe in our study, and the area and pressure of probe application and positioning of the patient were well controlled. Accordingly, different responses by laser irradiation obtained in our study indicate that sensitivity of individuals to laser is different depending on patients' pathophysiology.

Stellate ganglion block has some severe potential complications such as the accidental injection of local anesthetics into the vertebral artery, pneumothorax, recurrent nerve block and brachial plexus block. Laser irradiation near the stellate ganglion, however, is non-invasive and has no such complications. Laser irradiation near the stellate ganglion can be safely performed even for the elderly who are usually candidates for stellate ganglion block.

Conclusions

In conclusion, our double blind, crossover, and randomized placebo-controlled study indicate that laser irradiation on the area near the stellate ganglion increases regional skin temperature and decreases pain intensity in patients with postherpetic neuralgia. These findings are not placebo effects, but are dose-dependent laser mediated effects.

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