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Original Article

Clinical Effect of CO_2 Laser in Reducing Pain in Orthodontics

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ABSTRACT

Objective: To test the hypothesis that there is no difference in the pain associated with orthodontic force application after the application of local CO_2 laser irradiation to the teeth involved.

Materials and Methods: Separation modules were placed at the distal contacts of the maxillary first molars in 90 patients in this single-blinded study. In 60 of these patients (42 females and 18 males; mean age = 19.22 years) this was immediately followed by laser therapy. The other 30 patients (18 females and 12 males; mean age = 18.8 years) did not receive active laser irradiation. Patients were then instructed to rate their levels of pain on a visual analog scale over time, and the amount of tooth movement was analyzed.

Results: Significant pain reductions were observed with laser treatment from immediately after insertion of separators through day 4, but no differences from the nonirradiated control side were noted thereafter. No significant difference was noted in the amount of tooth movement between the irradiated and nonirradiated group.

Conclusions: The hypothesis was rejected. The results suggest that local CO_2 laser irradiation will reduce pain associated with orthodontic force application without interfering with the tooth movement.

KEY WORDS: CO_2 laser; Pain; Orthodontics

INTRODUCTION

Patients often feel pain or discomfort when exposed to orthodontic forces.[1] Not only does severe pain appear immediately after the force application, but it also lasts several days after the initiation of tooth movement.[2]

Pain from orthodontic treatment is mostly local and therefore may be controlled more efficiently by locally administered analgesic treatment. One suggested method to control pain is laser therapy.[3–7] Two types of laser have recently become available for dental applications. One type, which includes CO_2 and Er:YAG lasers, is absorbed by only a thin surface layer of tissue. The other type penetrates into deeper tissue and includes Nd:YAG, He:Ne, and semiconductor lasers. Several studies have reported analgesic effects of the tissue-penetrating Nd:YAG,[3] He:Ne,[4] and semiconductor lasers[5–7] for reducing orthodontic pain.

Nd:YAG and semiconductor lasers are known to produce higher temperatures than CO_2 lasers, which may result in heat-induced tissue necrosis.[8,9] The CO_2 laser procedure is known to result in little bleeding and hardly any pain during turbinectomy and has higher patient-satisfaction rates than Nd:YAG laser therapy.[10] Moreover, during wound healing in bone, the CO_2 laser is known to result in a greater amount of bone regeneration after the irradiation compared with Nd: YAG lasers.[11] Thus, reducing pain with less tissue damage may be possible during orthodontic treatment with the use of CO_2 laser. However, to our knowledge

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there has been no report on the effect of superficially absorbed type of lasers during orthodontic tooth movement.

High-level CO_2 laser therapy (HLLT) is known to produce a photobiodestructive reaction to induce cellular vaporization, whereas low-level CO_2 laser therapy (LLLT) generates a photobioactive reaction (PAR) to stimulate cellular proliferation and differentiation.[12] Pinheiro et al[13] and Simunovic[14] reported on the efficacy of LLLT in reducing pain in patients with temporomandibular joint dysfunction. CO_2 lasers are highly capable of promoting wound healing[15,16] and can penetrate deeper than the superficial tissue layer. Thus, LLLT may be very effective in reducing pain induced by local noxious stimuli.

The present study was conducted to evaluate the effect of CO_2 laser application in alleviating orthodontic pain. The hypothesis was that there is no difference in the pain associated with orthodontic force application after the application of local CO_2 laser irradiation to the teeth involved. In addition, we have analyzed the effect of CO_2 laser on orthodontic tooth movement.

MATERIALS AND METHODS

Separation modules were placed at the mesial and distal contacts of the maxillary first molars in 90 patients in this single-blind study. Participation in the study was based on the following criteria:

- No history of previous orthodontic treatment
- No significant medical history, such as diabetes and metabolic diseases
- All teeth to the second molars were fully erupted before orthodontic treatment began
- No evident periodontal or gingival problems at the beginning of orthodontic treatment

The patients had all consented to be participants of the present study before the start of orthodontic treatment. The study protocol was reviewed and approved by the Institutional Board of Okayama University.

A total of 60 patients (mean age $=$ 19.22 years), 18 males (mean age $=$ 18.53 $\pm$ 2.24 years) and 42 females (mean age 19.51 $\pm$ 2.23 years), were included in the laser-treated group (separators with laser therapy; SL group). In these 60 patients the separators were immediately followed by laser therapy to the left molars. The other 30 subjects with separators did not receive any laser treatment (separators without laser therapy group; S group).

For the 60 test subjects, 20 CO_2 laser pulses of 2 W output and 5 pulses per 1000 seconds duration (Bel-Luxar, Takara Belmont Corporation, Osaka, Japan) were applied at a 2-mm defocus 30 seconds after separator placement over a period of 30 seconds each, for a total of 1 minute. The laser was applied only to the left maxillary teeth from the buccal and palatal gingiva from their cervical margins to the apical levels of the maxillary left second premolar. A single operator performed all separator insertions and laser applications. Because of intersubject variability in pain threshold and sensitivity, the right side of the dentition was not irradiated and served as an intrasubject control.

All 90 subjects were instructed to mark their level of pain on a 10-cm visual analog scale (VAS) at 30 seconds, at 6 and 12 hours, and at 1, 2, 3, 4, 5, 6, and 7 days after separation placement. The mark was measured with a 10-cm ruler from the left side in millimeters. Each millimeter was given a VAS score of 1 so that the score of 0 at the left end of the scale indicated no pain, a score of 100 at the right end of the scale was regarded as maximum pain, and a score of 50 in the center indicated moderate pain. This was explained to each subject before the study.

The amount of tooth movement was analyzed for all 90 patients. For the tooth movement analysis, dental casts taken before and after the separation modules were used. The measurement was performed between the second premolar and the first molar using a digital caliper (Shinwa Co, Osaka, Japan).

The Friedman 2-way analysis of variance of rank was used for statistical analysis of observed differences in VAS score and in the amount of tooth movement between the irradiated and nonirradiated sides and between the groups at each time point in the study.

RESULTS

Because there was no significant difference in age among the examined patients, the VAS data were combined for all subjects within each group for statistical analysis. In the S group, the level of pain peaked 24 hours after separator insertion and was minimal at 1 week (Figure 1).

Compared with the score 30 seconds after the separation, significantly higher VAS scores were observed from 6 hours to 3 days, and significantly lower VAS scores were observed from 4 to 7 days (Figure 1). No significant differences were seen in the VAS scores and their time course between right and left sides in the S group (Figure 1). The VAS scores for the control side of the SL group were similar to those of the S group throughout the experimental period (Figures 1 and 2).

Of the 60 patients in the SL group, 50 felt pain upon separator placement and 10 did not. The mean VAS scores for the control and irradiated sides, respectively, in the SL group were 48 and 40 at 30 seconds, 61 and 37 at 6 hours, 72 and 42 at 12 hours, 79 and 44

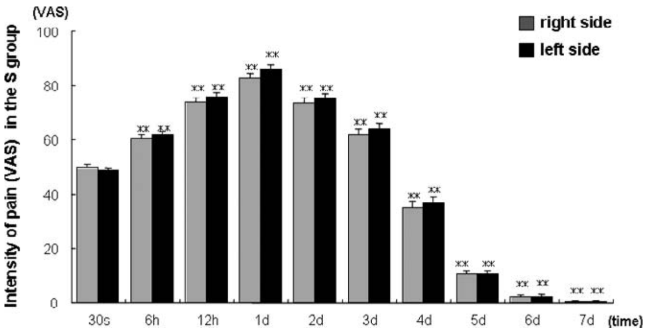

Figure 1. Comparison of mean intensity of pain by visual analog scale scores in the separators without laser therapy group. **Significant difference compared with measures immediately after separation (after 30 seconds; $P < .05$; n = 30). S indicates seconds; h, hours; d, days.

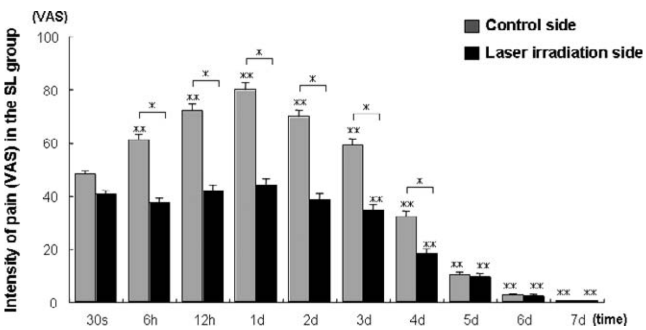

Figure 2. Comparison of mean intensity of pain by visual analog scale scores in the separators with laser therapy. *Significant difference within group ($P < .05$). **Significant difference compared with measures immediately after separation (after 30 seconds; $P < .05$; n = 60). S indicates seconds; h, hours; d, days.

at 24 hours, 70 and 38 at 2 days, 59 and 34 at 3 days, and 32 and 18 at 4 days after separator placement (Figure 2). The differences between the two sides were statistically significant through day 4 ($P < .01$) (Figure 2) but not thereafter. Within the nonirradiated control side in the SL group, significantly higher ($P < .01$) VAS scores were observed from 6 hours to 3 days compared with 30 seconds after the insertion of elastic (Figure 2). In addition, significantly lower ($P < .01$) VAS scores were observed from 4 days to 7 days after the insertion of the elastic in the nonirradiated side in SL group compared with 30 seconds after insertion (Figure 2). On the other hand, among the laser-irradiated side in the SL group, significantly lower ($P < .05$) VAS scores were observed from 3 days to 7 days after the insertion of the elastic (Figure 2).

Analysis of amount of tooth movement showed an average of 0.78 ± 0.08 mm (n = 60, mean ± SD) in the laser-irradiated groups and 0.70 ± 0.11 mm (n = 60) in the nonirradiated groups. No statistical significance was found in the amount of tooth movement between the nonirradiated control and irradiated experimental group.

DISCUSSION

In the present study, the VAS scores and their time course for the nonirradiated side of the laser treatment in the SL group were similar to those for the S group. The results obtained for the nonirradiated side of the laser treatment S group could thus be regarded as reliable data. Orthodontic pain, a type of pain seldom encountered in daily life, will be a new experience for patients without previous orthodontic treatment. They may feel the pain differently from previously treated patients or those under treatment. Therefore, this study excluded patients with previous orthodontic treatment to eliminate potential effects of past experience on pain threshold.

Direct assessment of orthodontic pain and its time course is very difficult because of the subjective nature of the pain and individual variability in pain threshold and sensitivity. Studies on pain associated with orthodontic appliances have been conducted using patient questionnaires and VAS.[17–19] This method facilitates the assessment of changes in pain intensity over time and is reported to be useful in investigating the analgesic effect of anti-inflammatory drugs.[17] The present study also used a VAS to closely examine changes in the levels of pain over time after CO_2 laser treatment compared with placebo. Ngan et al [19] used a VAS to evaluate the time course of discomfort level after insertion of orthodontic separators and an initial arch wire and found no significant difference in discomfort between the sexes or age groups. The present study enrolled patients between 16 and 23 years old with fully erupted second molars at a male-to-female ratio of 18:42. Because no significant difference was observed by age or gender, the VAS scores obtained were combined for all patients in the group for analysis.

Furstman and Bernick[18] reported that pain tended to appear approximately 2 hours after appliance placement. Ngan et al[19] determined the level of discomfort at 4 hours, 24 hours, and 7 days after insertion of separators and an initial arch wire compared with before insertion; peak levels of discomfort were reported at 24 hours for both appliances. Harazaki and Isshiki[3] analyzed the time course of pain intensity using a questionnaire given to patients who had an edgewise appliance and an initial arch wire placed. They observed that pain started about 3 hours after appliance placement, peaked at about 24 hours, and almost disappeared at 1 week. These studies indicate that the patient feels the pain most frequently at 24 hours, followed by gradual recovery. The present study also showed a peak pain level at 24 hours and a minimal level at 1 week.

The immediate-phase pain induced by orthodontic treatment was significantly reduced with local CO_2 laser applications, which is consistent with findings of a previous study using semiconductor lasers.[5–7] In contrast with a previous study that reported no pain relief after 54 hours of initiation of orthodontic force,[7] the significant pain relief ($P < .01$) was sustained for a longer period (4 days) after separator insertion in this study. In the study comparing the surgery (turbinectomy) and the recovery effect between the CO_2 laser and Nd:YAG laser, less pain and faster recovery was observed in the CO_2 laser group.[10] Thus, the difference may indicate that CO_2 laser applications have prolonged analgesic effects compared with other types of laser. However, no differences were seen from day 5, which may be attributed to spontaneous pain reduction to VAS scores of below 10 on the control side. Furthermore, the placebo group showed no difference between the two sides, and their levels of pain were similar to those scored on the nonirradiated control side in the laser-treatment group throughout the study period. These findings showed the efficacy of local CO_2 laser irradiation in reducing pain accompanying orthodontic tooth movement. In addition, further investigation (questionnaires) may be necessary to elucidate the problems with regard to not only pain but also other unpleasant sensations or feelings of discomfort to patients.

Laser irradiation is reported to improve the peripheral circulation, oxygenate hypoxic cells, and help remove noxious products.[13] There are also reports on the effect of LLLT in inhibiting the production of inflammatory mediators, such as prostaglandin E_2 and interleukin 1-β.[20–22] Furthermore, we have recently investigated the mechanism in rats and found that the neuropeptides in the peripheral and central nervous system tend to decrease during tooth movement with CO_2 laser application (data not shown). From these data, LLLT appears to have multiple mechanisms of action, including elevating body surface temperature, removing pain-inducing substances through increased local circulation, and inhibiting the production of inflammatory factors. Thus, LLLT may play a role during the inflammatory process that occurs in orthodontic treatment. Other biological effects of LLLT include metabolic enhancement[23] and acceleration of wound healing through stimulation of fibroblast formation.[24,25]

With regard to the analysis in the amount of tooth movement, a previous study in rats showed 30% more tooth movement in the high-dose laser-irradiated group than in the nonirradiated group.[26] On the other hand, a recent study in humans analyzed the effect of gallium aluminum arsenide (GaAlAs) LLLT with low doses and reported no significant difference in the amount of tooth movement between the irradiated and nonirradiated groups.[27] In the present study, there was no significant difference in the amount of tooth movement between the irradiated and nonirradiated group with approximately the same dose as the GaAlAs LLT study. Thus, we suggest that LLLT CO_2 laser does not have a negative effect on the amount of tooth movement. However, the results may differ by analyzing the amount of tooth movement during active edgewise treatment with a longer observation period. Because much remains unknown about LLLT, further studies are needed to elucidate its mechanism of action in reducing orthodontic pain.

CONCLUSIONS

- The hypothesis is rejected. These results suggest that local CO_2 laser irradiation will reduce pain associated with orthodontic force application without interfering with tooth movement.

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