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The Use of Locally Applied Vibration to Minimize Pain during Fractional CO_2 Laser Therapy in Living Liver-Donor Scar Management

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Background Fractional CO_2 laser is an effective treatment for scars, but most patients complain about sharp burning pain, even after the application of lidocaine ointment. This study analyzed the impact of a vibrating device to nonpharmacologically reduce the acute pain of laser treatment, in accordance with the gate control theory of pain management.

Methods This is a prospective study performed from May 2013 through March 2014. Fifty-three patients (mean age, 26.7 years; range, 16–44 years) who had donated livers for liver transplantation were treated with a fractional CO_2 laser (10,600 nm; model eCO_2, Lutronic Corp) for their abdomen scars. Laser treatment was applied 4 months after surgery. A commercially available, locally applied vibrating device (model UM-30M, Unix Electronics Co. Ltd.) was used, in an on-and-off pattern, together with the CO_2 laser. A visual analogue scale (VAS; 0, no pain; 10, most severe pain) of pain sensation was assessed and statistically analyzed using a paired t-test.

Results The average VAS score for pain with the vibrating device was 4.60 and the average VAS score without the vibrating device was 6.11. The average difference between scores was 1.51 (P = 0.001).

Conclusions A locally applied vibrating device was demonstrated to be effective in reducing pain when treating with a fractional CO_2 laser. Vibration treatment could be helpful when treating scars with fractional CO_2 laser in pain-sensitive patients, particularly children.

Keywords Vibration / Lasers / Pain management

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INTRODUCTION

The fractional CO_2 laser is one of the most common and widespread modalities for treating scars. It can, however, be a source of sharp burning pain and distress, particularly in the pediatric population. Therefore, treatment with a fractional CO_2 laser may be associated with greater anxiety, avoidance, and greater parental distress. A painful laser procedure may result in enhanced pain sensitivity and a maladaptive pain response that may persist throughout adolescence. Consequently, children and their parents may delay treatment and avoid clinical settings [1]. In contrast, positive or neutral past experiences, regardless of the quantity, appear to have no significant impact on the child's distress or cooperation [2].

Multiple techniques currently exist to manage acute pain during the laser procedure. Pharmacological approaches include

topical anesthetic creams and vapocoolant sprays [2,3]. Nonpharmacological approaches include pinching, rubbing, and distraction [4]. Although data supporting each of these strategies exist, each strategy has certain limitations. For example, topical anesthetics such as lidocaine (Eutectic Mixture of Local Anesthetics [EMLA], AstraZeneca, London, UK) may require relatively long periods of time for optimal analgesic effect, thereby limiting their usefulness in a busy outpatient setting [5]. In contrast, vapocoolant sprays may provide skin anesthesia within seconds of application; however, reports of their effectiveness are inconsistent [3,6-8]. To overcome the limitations of existing methods, a locally applied vibrator was devised to significantly alleviate the pain associated with a successful laser procedure. This technique, which is inspired by the gate control theory of pain management, nonpharmacologically alleviates the acute pain that accompanies a laser procedure [9]. The Buzzy (MMJ Labs, Atlanta, GA, USA) is a useful example of a reusable vibrating device that has been designed to be placed on the skin for the amelioration of sharp, burning, and itching pain. Unfortunately, studies have been limited to injection pain. The purpose of this study was to assess the efficacy of a locally applied vibrating device on reported pain in living liver-donor patients undergoing outpatient CO_2 laser procedures to repair scars. We hypothesized that this use of vibration could decrease the reported pain associated with CO_2 laser treatment without significantly disrupting scar management.

METHODS

This is a prospective designed study performed from May 2013 through March 2014. Fifty-three patients (age range, 16–44 years) who had donated a liver for liver transplantation were treated with fractional CO_2 laser (10,600 nm; model eCO_2, Lutronic Corp., Goyang, Korea) on their abdominal scars. The surgeries were performed by general surgeons, who also closed the wounds. The CO_2 laser was applied 4 months after surgery. The applied energy was 120 J (n = 14), 140 J (n = 33), or 160 J (n = 6), and the power was 30 W. The density was set to 150 spots/cm^2. The laser was applied to the patient's abdomen along the incision line, which extended from the xiphoid process to the right flank via the umbilicus. The mean scar length was 200.5 mm (range, 95–320 mm) and the mean scar width was 4.1 mm (range, 1.5–10 mm) and the extent ranged from 0.28 to 32 cm^2. All the patients were initially treated with topical lidocaine cream (EMLA, AstraZeneca) 40 minutes before laser therapy. The vibrating device (model UM-30M, Unix Electronics Co. Ltd., Seoul, Korea) (Fig. 1), which had a 60-Hz vibration frequency, was employed after cleaning off the residual cream. Application of the device began from just before the start of the fractional CO_2 laser treatment until the procedure was finished. The vibrator handle was fully rotated by 30° at a time, and we could adjust the power of the vibrator (weak/strong) depending on the patients' preferences (Fig. 2) (Supplemental Video S1). The visual analogue scale (VAS) scores with or without vi-

Fig.1. Vibrator device

Model UM-30M Unix Electronics Co. Ltd., Seoul, Korea.

Fig. 2. Applying the vibrator device during CO_2 laser therapy

60-Hz vibration frequency was employed just before the start of the fractional CO_2 laser treatment.

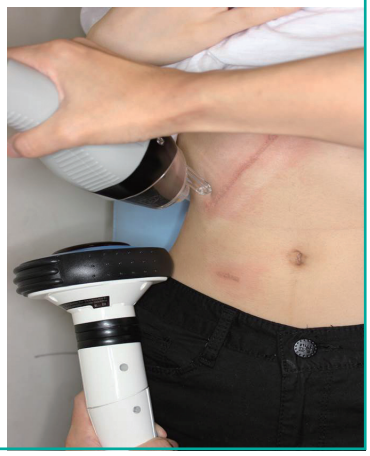

Fig. 3. Visual analogue scale mean score

NRS, numerical rating scale; VRS, verbal rating scale; VAS, visual analogue scale.

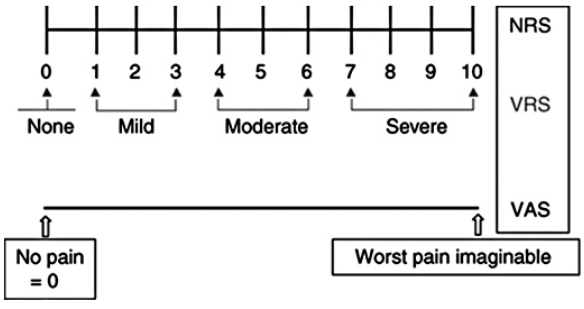

Table 1. Pain scale comparison with and without vibrator device

Condition	No.	Mean	Minimum	Maximum	P-value
Pain scale with vibrator	53	4.60 ± 2.43	1	10	0.001
Pain scale without vibrator	53	6.11 ± 2.50	0	10	0.001

bration were compared (Fig. 3). VAS scores (0, no pain; 10, most severe pain) for pain sensation were assessed and statistically analyzed using a paired t-test. We used SPSS ver. 21 (IBM Corp., Armonk, NY, USA) for statistical analysis.

This study reviewed data collected prospectively as a part of a preimplementation and post-implementation quality improvement program. The data contained no personal health information and the Institutional Review Board approved the study. For collecting pain scores, we used the VAS psychometric response scale, which can be used in questionnaires. The VAS is an instrument for assessing subjective characteristics or attitudes that cannot be directly measured. When responding to VAS questionnaires, patients specify their level of agreement with a statement indicating a position along a continuous line between 2 end-points. Patients participating in the study and their families were provided a questionnaire to complete after the procedure. The forms were both completed and collected anonymously such that the investigators could not link the responses on any survey to a specific patient. Whenever possible, a child patient was encouraged to complete as much of the questionnaire as possible. We asked patients, "Do you want to undergo a procedure for relieving pain?" "How is your VAS score?", and "Would you like to use this machine again if you underwent fractional CO_2 laser therapy?" "Would you like it to be used for future venipunctures?" In those cases where the child could not, or chose not to complete the questionnaire, the accompanying parent completed the form with the child's input as much as possible. After collecting this baseline information, a protocol was instituted for the use of the vibrating device. Analysis consisted primarily of descriptive statistics, which included means and standard deviations as well as medians and interquartile ranges. A P-value of < 0.05 was considered to be statistically significant.

RESULTS

Fifty-three patients participated in the study; results were collected separately on the same patient with or without the vibrator device. The mean age of the group, which consisted of 19 males and 34 females, was 26.7 (range, 16–44 years). Their mean body mass index was 22.49 kg/m^2 (range, 14.18–30.18 kg/m^2). Their mean scar length was 200.5 mm (range, 95–320 mm) and the mean scar width was 4.1 mm (range, 1.5–10 mm); the extent ranged from 0.28 cm^2 to 32 cm^2. The mean time from surgery to laser procedure was 124 days (range, 80–170 days). The pre- and post-vibration implementation cohorts compared results within the same group of patients. Of the 53 patients who participated, 34 (64.1%) indicated that they felt reduced pain and 19 (35.9%) claimed that they felt similar or greater pain after the vibrating device was applied. The mean VAS score before vibration implementation was 6.11, and the mean VAS score after vibration implementation was 4.6 (Table 1). The reduction in mean VAS score (1.51) is statistically significant ($P = 0.001$). Thirty-two patients (60.3%) indicated via the VAS questionnaire that they would like the vibration technique to be used again during their next fractional CO_2 laser treatment. Some pediatric patients specifically asked to use the vibrating device to reduce pain and distress from the laser procedure. Nineteen patients (35.8%) reported mild pain (VAS score 1–3) after the vibrating device was applied. Seven patients (13.2%) reported reduced pain after the vibrating device was applied, but still reported moderate to severe pain (VAS score 4–8).

DISCUSSION

The pervasiveness of outpatient laser-related procedures and their accompanying potential for physical and emotional pain has generated a need for relevant pain management strategies. Of the children surveyed in this study before the implementation of the vibration technique, nearly 60% indicated that they wished a treatment had been available before the fractional CO_2 laser to reduce the pain. Although this demonstration of clear efficacy in pain management was limited by its small sample size, differences in the patients' sensitivity to pain, and the subjective nature of the VAS, this study's results suggest that the use of vibration is practical and acceptable to patients. A total of 60% of patients requested the use of this device for their next fractional CO_2 laser treatment. The negative consequences accompanying a painful fractional CO_2 laser treatment range from immediate effects, such as the lack of cooperation by the child, physiological responses that may complicate venous access attempts, and prolonged procedure time, to long-term reactions that include avoidance of future fractional CO_2 laser treatments [10]. Children often become agitated, complicating venous access attempts and impeding a precise procedure; however, im-

plementing the vibration technique decreased their pain and helped gain their cooperation, enabling the correct amount of laser treatment to be applied in an exact procedure area.

Other techniques are available to minimize the pain and distress associated with fractional CO_2 laser treatment; however, all are associated with limitations that impact their clinical utility. For example, topical anesthetics such as lidocaine and tetracaine hydrochloride are well established in this setting, but they require anywhere from 30 minutes to 2 hours for efficacy [5]. Moreover, an application appropriately timed with fractional CO_2 laser treatment does not ensure success; the cream may come off during the interim or be inappropriately placed, rendering the treatment ineffective. Vapocoolant sprays represent another treatment option for venipuncture-associated pain [3]. Although these sprays can provide rapid and relatively inexpensive analgesia, patients may perceive them as another noxious stimulus [3]. Furthermore, reports of their efficacy in the literature have been inconsistent [3,6].

Various distraction strategies may also be useful; however, they require the engagement of a nurse, parent, or phlebotomist, which is often not practical in a fast-paced medical setting. Vibration is a practical tool for venipuncture in the outpatient setting. As described above, the ability to demonstrate clear efficacy was limited by the small sample size, the patients' individual sensitivity to pain, and the subjective nature of the VAS. However, the finding that 60% of the patients that received the vibration technique indicated that they would like it to be used for future venipunctures provides evidence of its perceived efficacy.

The usefulness of the vibration device is based on the gate control theory recently reported by Melzack and Wall [9,11]. Afferent signals mediated by large myelinated fibers inhibit small pain fibers presynaptically in the dorsal horn of the spinal cord. This hypothesis is supported by the analgesic effect of transcutaneous electrical nerve stimulation (TENS) of the peripheral nerves. The effects of TENS on the waveforms of electrically stimulated somatosensory evoked potentials was reported in work elucidating the analgesic effects of TENS, but electric stimuli are not appropriate for the objective described above [12]. In addition to vibration therapy, there are other methods for pain relief based on the gate control theory, including cold therapy in the form of a vapocoolant spray (Painease, Gebauer Co., Cleveland, OH, USA) [13].

Whole-body vibration is a relatively unexplored therapeutic modality, having only been used previously for strength, conditioning, and neuromuscular training purposes. Although whole-body vibration has recently been shown to improve strength and balance in clinical populations with stroke, fibromyalgia, and Parkinson disease, it has yet to be applied as a treatment modality for controlling pain and improving mobility disorders. In one report, whole body vibration was shown to reduce neuropathic pain and improve gait in a patient with type II diabetic peripheral neuropathy [14].

Even though this vibrating device was not invented for pain control (its practical usage is mechanical muscle relaxation), the vibrating device has been found to significantly decrease both pain and anxiety. However, the response to vibration use was so overwhelmingly positive that the clinical equipoise for further study was lost. Another inherent weakness of this study was the inability to mask the treatment from either the patient or the physician. Although all responses were anonymous, it is plausible that the patients could have assumed that a positive response was desired and responded in that manner. Additionally, the physician could have been favorably biased during their training on the use of the vibrating device, which fostered their positive reviews.

In summary, despite these acknowledged limitations, the findings of this report suggest that the use of a locally applied vibrating device is a practical and acceptable method to decrease perceived pain during fractional CO_2 laser treatment and to facilitate successful procedure completion within the outpatient setting. At a minimum, these findings suggest that a future randomized, controlled study is warranted to replicate these findings and to determine its efficacy in an expanded population. In addition, further study is warranted on the effect of vibration for reducing pain in comparison to topical anesthetic cream or coolant application with the same condition, on the same patients.

The ability to provide pain control services in a timely and acceptable manner will continue to grow in importance as a component of care. The results of this study suggest that locally applied vibration may effectively satisfy that role. Its ease of use, rapid onset, lack of side effects, physician acceptance, and low cost could overcome many of the barriers that plague other current pain management strategies.

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Supplemental Video S1. How to apply the vibrating device during CO_2 laser therapy.

Summary of categories definition Supplemental data can be found at: http://e-aps.org/src/sm/aps-43-570-s001.avi