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Vibration for Pain Reduction in a Plastic Surgery Clinic

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Patients can experience significant pain during routine procedures in the plastic surgery clinic. Methods for clinical pain reduction are often impractical, time-consuming, or ineffective. Vibration is a safe, inexpensive, and highly applicable modality for pain reduction that can be readily utilized for a wide variety of procedures. This study evaluated the use of vibration as a viable pain-reduction strategy in the clinical plastic surgery setting. Patients requiring at least 2 consecutive procedures that are considered painful were enrolled in the study. These included injections, staple removal, and suture removal. In the same patient, one half of the procedures were performed without vibration and the other half with vibration. After completing the procedures, the patients rated their pain with vibration and without vibration. The patient and the researcher also described the experience with a short questionnaire. Twenty-eight patients were enrolled in the study. Patients reported significantly less pain on the Numeric Rating Scale pain scale when vibration was used compared with the control group ($p < .001$). The average pain score was 3.46 without vibration and 1.93 with vibration, and vibration with injections resulted in the greatest improvement. Eighty-six percent of the patients claimed that vibration significantly reduced their pain. Vibration is an effective method of pain reduction. It significantly reduces the pain experienced by patients during minor office procedures. Given its practicality and ease of use, it is a welcome tool in the plastic surgery clinic.

Injections, staple removal, and suture removal in the outpatient setting can be a significant source of pain for patients in the plastic surgery clinic. Patients often request extended periods of time for these procedures, which occupy the nursing staff and cause delays in patient care. In addition, many procedures may be avoided or deferred by the patient because of fear of pain from a previous experience. Few modalities have been tested to alleviate this pain, although "EMLA" cream, skin cooling, and transdermal anesthetics have been shown to alleviate some of the pain (Banwell, Deakin, Holden, & Powell, 1997; Farroha, Frew, & Shelley, 2012). These modalities may be costly, are time-consuming, and may not be suitable for use with open wounds.

Vibration is defined as a rapidly oscillating or periodic movement. It is an inexpensive and highly applicable modality for pain reduction that takes advantage of the "gate theory" of pain sensation (Nanitsos, Vartuli, Forte, Dennison, & Peck, 2009; Pantaleo, Duranti, & Bellini, 1986; Roy, Hollins, & Maixner, 2003; Shahidi Bonjar, 2011). Small peripheral fibers transmit pain and large peripheral fibers transmit vibration to the central nervous system. It has been shown that stimulation of large fibers reduces the sensation of pain by occupying the central

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DOI: 10.1097/PSN.0000000000000134

Presented as an abstract at the 2015 American Association of Plastic Surgeons Meeting; the abstract is available in associated *Plastic and Reconstructive Surgery* journal.

Author roles: M.G.E.—idea, data collection, manuscript preparation; M.J.K.—data collection, manuscript preparation; J.R.K.—data collection, manuscript preparation; D.M.F.—data collection, manuscript preparation; R.D.F.—data collection, manuscript preparation.

The authors have no conflicts of interest or financial relationships to disclose. The authors received no compensation.

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nervous system with non-noxious stimuli, impairing its ability to detect concurrent noxious stimuli from the same sensory area (Shahidi Bonjar, 2011). In preliminary clinical studies, vibration has been shown to reduce musculoskeletal pain and pain with dental injections (Nanitsos et al., 2009; Pantaleo et al., 1986; Roy et al., 2003). It also significantly increases cutaneous pain thresholds during blood specimen collection (Inal & Kelleci, 2012; Zoppi, Voegelin, Signorini, & Zamponi, 1991). Vibration lacks the side effects that are commonly seen in pain medications and can be used in patients of all ages instantly without risk.

This purpose of this study was to evaluate vibration as a viable pain-reduction strategy in the clinical plastic surgery setting.

MATERIALS AND METHODS

This randomized, prospective, matched-pair study was approved by the local institutional review board. The research was conducted at a hand and plastic surgery clinic and was administered by the authors. Patients were offered enrollment in the study if they required at least two consecutive and similar procedures that are typically considered painful. These procedures included injections, suture removal, and staple removal. Patients receiving local anesthetic injections were excluded from the study to eliminate potential confounding factors, as were patients with peripheral neuropathy. There were no age requirements; however, participants had to have the ability to communicate their pain coherently on a pain scale. A signed written consent was obtained from each patient prior to enrollment in the study. This study was performed in accordance with the Declaration of Helsinki.

Patients enrolled in the study, first, had their staples, sutures, injections, or total number of procedures counted and divided in half. One half of the procedures would be performed without vibration, the other half with vibration. A randomization schedule determined whether vibration would be used first or second. The vibration device used was the DentalVibe (DentalVibe, Boca Raton, FL), a cordless handheld instrument with disposable tips that was originally designed for dental injections (Figure 1). A second-generation DentalVibe was loaned to the authors to be used for this study; the current model is the fourth-generation DentalVibe. The DentalVibe is a Food and Drug Administration-approved device that is used to relieve pain during injections. The authors additionally investigated its use to relieve pain during suture and staple removal.

In the vibration wing of the study, the "DentalVibe" was turned on and pressed onto the skin immediately adjacent to the suture, staple, or injection site (Figure 2). The procedure was then performed and the same process was repeated until all vibratory procedures were completed. The researcher or an assistant applied the vibration. For the control wing, without vibration, the procedures were simply performed in the standard fashion.

FIGURE 1. Second-generation DentalVibe vibrator. The device has disposable plastic tip attachments and can be activated with one hand.

Immediately after finishing both wings of the study on a given patient, the patient and the researcher were asked to complete a form describing the experience. Patients rated their pain both with and without vibration on the 11-point Numeric Rating Scale (NRS; van Dijk, Kappen, Schuurmans, & van Wijck, 2015). They were also asked whether vibration significantly reduced their pain and whether they would request vibration for a similar procedure in the future.

The location and type of procedure, as well as basic demographic information, were recorded. The researchers were asked whether the patients appeared to be in more or less pain with vibration and whether the application of vibration affected their ability to perform the procedure. After the procedure, the used disposable tip was removed, the device was cleaned with alcohol, and a new clean tip was used for each patient.

Statistical analysis for comparisons between the vibration and control groups was performed with a matched-pair two-tailed t test. Significance defined as a p value of less than .05. Comparisons were performed for the study population as a whole and for each procedural group.

RESULTS

Twenty-eight patients were enrolled in the study; the average age was 54 years, and 75% were female. Fourteen patients had injections, 9 of which were Botox injections, and 14 patients had suture or staple removal. Twelve

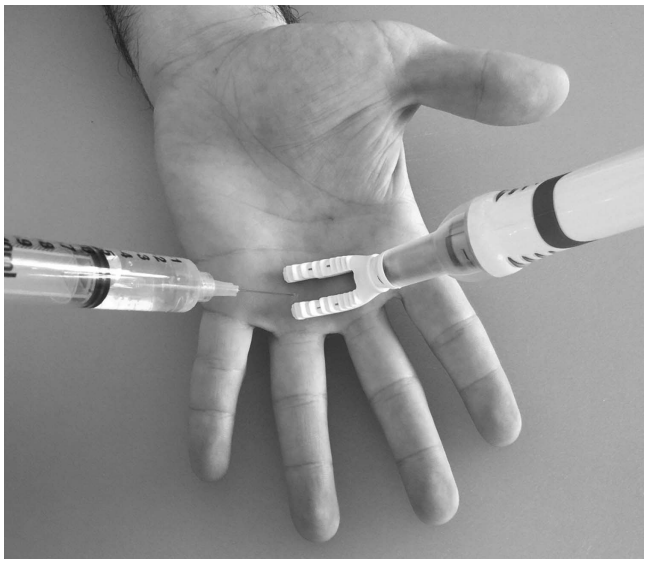

FIGURE 2. Vibration application. Application of the vibration device during an injection. Vibration is applied to the area before injection and is continued throughout the injection.

patients had procedures performed on the upper extremities, one on the lower extremity, and 15 on the face or scalp (Table 1).

Patients reported significantly less pain on the NRS pain scale when vibration was used compared with the control group ($p < .001$). The average pain score without vibration was 3.52, and the average pain score with vibration was 1.93. Vibration resulted in a decrease in reported pain scores by 44%. In addition to the injection group, this significance remained in the suture and staple removal group, and vibration with injections resulted in the greatest reduction in pain (Table 2). There was also significant reduction in NRS pain scores in each of the two major body areas we studied, the upper extremity and the face, when vibration was used. The greatest reduction in pain was seen in younger patients and in patients undergoing procedures on the face and the scalp.

There was no significant difference when controlling for age; patients both older and younger than 50 years reported similar pain scores. There was also no significant difference in NRS scores between the first (2.46) and second (2.92) sets of procedures, regardless of the randomization schedule ($p = .21$).

When patients were asked whether they would request vibration again for a similar procedure, 82% of participants responded favorably. Overall, 86% of the patients claimed that it significantly reduced their pain. Vibration appeared to reduce pain in 45% of the patients according to the researchers' subjective observations; no difference was perceived in 55% of the patients. The use of vibration did not impair the ability of the researchers to perform the procedures (Table 3).

TABLE 1 Demographics

Characteristic	Value
Age, years	
Mean	54
Range	27–93
Sex	
Female	21
Male	7
Procedures	
Staple/suture removal	28
Injection	14
Location	14
Upper extremity	12
Lower extremity	1
Face or scalp	15

DISCUSSION

Vibration as a pain-reduction modality has been explored in the dentistry literature and was shown to significantly decrease oral pain during local anesthetic injections (Hutchins, Young, Lackland, & Fishburne, 1997; Nanitsos et al., 2009). A later study in the pediatric population demonstrated no reduction in pain during intraoral injections (Roeber, Wallace, Rothe, Salama, & Allen, 2011). Multiple studies have shown that vibration reduces musculoskeletal pain (Lundeberg, 1983, 1984a, 1984b; Lundeberg, Abrahamsson, Bondesson, & Haker, 1988; Lundeberg, Nordemar, & Ottoson, 1984; Pantaleo et al., 1986; Roy et al., 2003). In a review of the literature, there have only been two clinical trials investigating its use for cutaneous needle pain (Fayers, Morris, & Dolman, 2010; Inal & Kelleci, 2012). In a large study by Inal and Kelleci (2012), vibration was effective at reducing pain during pediatric blood collection; however, this was performed in conjunction with skin cooling. Fayers et al. (2010) reported significant pain reduction with vibration during local anesthetic injections for eyelid surgery, with 75% of the participants reporting pain reduction. These results suggested that vibration could be a useful tool for cutaneous injections in other locations and could offer pain reduction for a broad spectrum of clinical procedures.

The mechanism of vibratory pain reduction is related to the "gate theory" of central nervous system sensory interpretation. Melzack and Wall (1965) first formulated this theory in 1965 after observations that a cutaneous itch could be alleviated with vibration (Fayers et al., 2010). The gate control theory hypothesizes that the stimulation of large fiber neurons interrupts the transmission of small fiber neuron signals (nociception) at the spinal cord

TABLE 2 Pain Scores With and Without Vibration

Patient Group	Pain Without Vibration[a]	Pain With Vibration[a]	Reduction
All patients	3.52	1.93	44%, $p < .001$
Suture/staple removal	2.93	1.64	44%, $p = .004$
Injections	4.00	2.21	45%, $p < .001$
Upper extremity	3.42	2.00	42%, $p = .002$
Face and scalp	3.67	1.93	47%, $p < .001$
Age >50 years	3.41	1.94	43%, $p = .001$
Age <50 years	3.54	1.91	46%, $p < .001$

[a]*Pain values as recorded from the 11-point Numeric Rating Scale. From van Dijk et al. (2015).*

by a complex process involving the activation of dorsal horn interneurons (Braz, Solorzano, Wang, & Basbaum, 2014). Vibration and fine touch are transmitted via the large fibers and can therefore reduce or eliminate the perception of pain when concurrently stimulated. Indeed, cutaneous pain thresholds have been proven to increase with vibratory stimulation (Dahlin, Lund, Lundeberg, & Molander, 2006; Zoppi et al., 1991). Contemporary theories on pain suggest that the process is more complex than this, but the original gate control theory has yet to be disproven (Braz et al., 2014).

Multiple techniques have been tested for pain relief during clinical procedures including EMLA cream (eutectic mixture of local anesthetics), audiovisual distraction, sedatives, skin cooling, sodium bicarbonate mixed with local anesthetics, and alternate injection techniques (Banwell et al., 1997; Farroha et al., 2012; Fayers et al., 2010; Nomura et al., 2014; Seo & Hong, 2009). EMLA cream has been proven to reduce pain but has variable penetration depth, requires time to properly anesthetize, and can be irritating to the eyes and mucous membranes. It takes up to 60 min for topical anesthetics to penetrate 3 mm (Fayers et al., 2010; Strazar, Leynes, & Lalonde, 2013). Skin cooling reduces pain during injections (Nomura et al., 2014; Seo & Hong, 2009), although the application of ice can become cumbersome and impractical if there are numerous staples or sutures to remove over a large area.

TABLE 3 Patient and Researcher Questionnaire

Question	Response
Would you request vibration again for a similar procedure?	Yes (82%)
Did vibration significantly improve your pain?	Yes (86%)
Did the use of vibration impair your ability to perform the procedure?	No (100%)

Note. The questionnaire was completed by the patient and the examiner immediately after the procedures were performed.

Buffering local anesthetic with sodium bicarbonate and warming the solution before injection significantly reduce pain (Strazar et al., 2013). A recent evidence-based review by Strazer et al. outlines techniques to reduce injection pain with local anesthetic. That study highlights the importance of small-diameter needles, proper needle stabilization and entry angle, injection depth and speed, and remaining within anesthetized areas. Unfortunately, these techniques are limited to injections, but they should be used whenever possible and can be combined with other methods of pain reduction (Strazar et al., 2013). The application of vibration does not preclude the use of the pain-reduction strategies mentioned earlier. Further studies are needed to investigate the combination of these techniques with vibration, as they may have additive or synergistic effects on pain reduction.

Most of the previous studies on vibratory pain reduction have focused on oral anesthetic injections or musculoskeletal pain, only two have investigated cutaneous injection pain, and none have studied its use for suture or staple removal (Fayers et al., 2010; Hutchins et al., 1997; Inal & Kelleci, 2012; Lundeberg, 1983, 1984a, 1984b; Lundeberg et al., 1984, 1988; Nanitsos et al., 2009; Pantaleo et al., 1986; Roeber et al., 2011; Roy et al., 2003; Saijo, Ito, Ichinohe, & Kaneko, 2005). Our patients had a significant reduction in pain during suture and staple removal and even a greater reduction during injections. It seems one of the most useful applications for vibration would be for Botox and filler injections, as these patients do not receive local anesthetics beforehand. The mechanical force of vibration did not cause inadvertent "spread" of the Botox or filler during any of our procedures.

Local anesthetic injections were not included in this study because of their potential to confound the results. It was thought that, with adjacent injections, the first injection would be more painful than the second irrespective of vibration. It can be assumed that vibration would work just as well with local anesthetic injections; this has been demonstrated in a recent publication on eyelid injections (Fayers et al., 2010).

There are a few key differences in the application of vibration in our study compared with other studies. Our device was applied at the immediate location of the pain source versus regionally as reported in Fayers et al. (2010). It is unknown whether vibration has an enhanced effect if it is closer to pain source. Our patients would place the DentalVibe adjacent to the procedure site if given the choice. Two studies used a vibrating needle instead of an external vibratory source for intraoral injections (Roeber et al., 2011; Saijo et al., 2005). These studies reported no significant reduction in pain with vibration. It is difficult to speculate why a vibrating needle would not reduce pain, although it could be due to excessive motion at the needle tip.

No complications were reported; the disposable head does need to be replaced between procedures to prevent cross contamination. One patient reported a mild "electric" sensation in his arm when vibration was being used for staple removal around his skin graft. This was in the area of the superficial branch of the radial nerve and was likely caused by direct nerve stimulation. He still rated his pain lower overall with vibration. Some of the patients undergoing staple and suture removal requested to administer the vibration themselves. They were able to move the vibration to the most painful area, and it did not interfere with the procedure.

There are some limitations to our study, most notably the inability to blind the patient and the researcher from the use of vibration. Pain can be difficult to measure because it is largely subjective and dependent upon psychological state. This study accounted for the inherent variabilities in different patient perceptions of pain; this was done simply by matching the test and control groups. By using patients as their own control, a myriad of confounding factors, including age, psychological state, and location, were accounted for.

The sample size was more than adequate to determine a significant difference, especially considering that this was a matched-pair study design. The finding of a significant difference, in itself, is considered evidence for an adequately powered study; however, a power analysis was performed to confirm. With a sample size of 28, the power for this study was calculated at greater than 99%. A power greater than 80% is the current standard.

The 11-point NRS is the current standard for acute pain research, and it is as effective as other pain rating scales (Breivik, Bjornsson, & Skovlund, 2000; van Dijk et al., 2015). The amount of pain deemed to be significant on the 11-point NRS is controversial (Fayers et al., 2010). For chronic pain conditions, an NRS reduction of 2 points is considered significant; however, no data on this topic exist for acute pain reduction (Fayers et al., 2010; Salaffi, Stancati, Silvestri, Ciapetti, & Grassi, 2004). Vibration reduced acute pain by 1.54 points in our patients, which exceeds a difference of 1.2 points in a similar study. The difference in NRS scores was statistically significant, and the majority of our patients (86%) reported a reduction in their pain with vibration. A nearly 50% reduction in pain was observed for younger patients, those undergoing facial procedures, and those undergoing injections. These findings suggest that vibration is particularly suited for Botox and filler injections.

CONCLUSION

Vibration is an instant, targeted pain-reduction strategy that can be applied to a wide range of procedures and anatomical sites safely and at a low cost. This rigorous study provides evidence for its effectiveness and significant pain reduction. It offers hesitant patients options they would not have considered otherwise and may increase the number or patients returning for elective procedures. Given its availability, ease of use, and significant pain reduction, it is a welcome tool in the plastic surgery clinic.

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Disclosure Statement: The authors and planners have disclosed that they have no financial relationships related to this article.

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DOI: 10.1097/PSN.0000000000000141