Pain control in orthodontics using vibration

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Pain is a common patient complaint during the orthodontic movement of teeth, especially immediately following archwire placement. Vibration has been used to accelerate the orthodontic movement of teeth and some observations by clinicians have indicated that vibration appeared to reduce the pain of orthodontic treatment. The purpose of this parallel group, randomized clinical trial was to investigate the relationship between a micro pulse vibration device and pain perception during orthodontic treatment. Fifty-eight patients meeting eligibility criteria were assigned using block allocation to one of two groups: an experimental group using the vibration device or the control group (n = 29 for each group). Patients used the device twenty minutes daily. Patients rated pain intensity on a visual analog scale at appropriate intervals during the weeks after the separator or archwire appointment. Data were analyzed using repeated measures analysis of variance at α = 0.05. Over the four month test period significant differences between the micro pulse vibration device group and the control group for overall pain (P = .002) and biting pain (P = .003) were identified. The authors observed that perceived pain was highest at the beginning of the month, following archwire adjustment. The micro pulse vibration device significantly lowered the pain scores for overall pain and biting pain over the four month study period.

Keywords: Pain; vibration therapy; orthodontics


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Introduction

Pain is a common occurrence during the orthodontic movement of teeth, especially immediately following archwire placement or adjustment. It is a complex phenomenon involving multiple variants and is influenced by factors such as age, gender, individual pain threshold and amount of force applied [1]. In orthodontics, a mechanical stimulus is introduced by placing fixed appliances on the teeth resulting in tooth movement. To achieve this movement, forces are applied to the dentoalveolar complex via fixed orthodontic brackets and wires resulting in inflammation or ischemia to the highly sensitive periodontal ligament (PDL) which surrounds the roots of the teeth with subsequent release of histamine, bradykinin, prostaglandins, substance P and serotonin [2]. These mediators stimulate local nerve endings and send pain signals to the brain.

Many methods have been used to alleviate pain arising from orthodontic origins. Non-steroidal anti-inflammatory drugs (NSAIDS) are the most common method to alleviate discomfort. NSAIDS block the formation of arachidonic acid via the cyclooxygenase pathway, reducing the production and release of prostaglandins.
The focus of our study was vibratory stimulation to reduce pain. Previous studies have demonstrated that vibration effectively reduces pain originating from teeth or the surrounding tissues. Vibration may help relieve compression of the PDL, promoting normal circulation to prevent the proliferation of inflammatory by-products. Another possibility is the “gate control” theory, which suggests pain can be reduced by simultaneous activation of nerve fibers that conduct non-noxious stimuli. Similar to the pain relieving effects from TENS, the effect of vibration seems consistent with the gate control theory, relying on activation of rapidly adapting mechanoreceptors in the skin, periosteum, muscle and bone, and an interaction between large fibers and small pain fibers. In essence, the receptors activated by vibration could mask the pain signals and prevent them from reaching the central nervous system (CNS). The possible release of endorphins secondary to the vibratory stimulus is another plausible theory.

AcceleDent® is patented as a “Vibrating Orthodontic Remodeling Device” (U.S. Department of Commerce's United States Patent and Trademark Office, 2013). It is an FDA approved, Class II medical device designed for faster orthodontic treatment. The manufacturer states that the device applies cyclic forces to the dentition for the safe acceleration of the bone remodeling process to complement conventional orthodontic treatment. The application of cyclical forces induces accelerated remodeling of alveolar bone. In a series of rabbit experiments, Mao demonstrated that cyclical forces applied at 2N with frequencies of 0.2 and 1Hz for 20 minutes daily, in conjunction with typical static orthodontic forces 24-hours per day, induced increased cranial growth, sutural separation, and proliferation of osteoblast-like cells. The primary purpose for using AcceleDent® is to decrease overall orthodontic treatment time. Moreover, cyclic force has been used and approved for use in other areas of the body (e.g., the Juvent™ 1000 device for maintaining and/or enhancing muscle strength, function, and postural stability).

There are reports from clinicians who have noticed pain reduction as an additional benefit for those patients using AcceleDent®. The purpose of our clinical study was to investigate the relationship between micro pulse vibration therapy for dental pain relief compared to a control group of no pain therapy during the first four months of orthodontic tooth movement and adjustment, and to see if age and gender were significant factors in the perception of orthodontic pain. This research highlight will familiarize readers with a clinical technique to reduce dental pain from the orthodontic movement of teeth that is relatively unexplored in dentistry—vibration.

### Methods

This parallel group, randomized clinical trial was approved by the local Institutional Review Board (IRB) and was determined to be no greater than minimal risk. It was determined that a sample size of thirty subjects per group would be sufficient to answer the research question at the 95% confidence interval. Pain scores were examined daily for the first week and weekly thereafter, and also by averaging the scores for a monthly score. A total of seventy subjects (thirty-five per treatment group) were selected from patients who presented for initial orthodontic treatment. Subjects were selected based on the following inclusion criteria: healthy child (age 10 and older) and adult patients approved for comprehensive orthodontic treatment. Subjects were recruited by orthodontic staff members and residents in the orthodontic department directly assigned to the study. Subjects were excluded from recruitment if the subject currently had any pre-existing pain conditions, or if the subject was not able to comply with the restriction on using any analgesic drugs (acetaminophen, ibuprofen, aspirin, topical anesthetic, etc.) during the course of the study.

### Table 1. Mean pain scores numerically generated from patients’ Visual Analogue Scale (VAS) information (0-100). P values are compared to the corresponding control groups.

<table>
<thead>
<tr>
<th>Overall Pain Score With Device</th>
<th>Overall Pain Score Control (no device)</th>
<th>Biting Pain Score With Device</th>
<th>Biting Pain Score Control (no device)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.78 (P=0.039)</td>
<td>17.20</td>
<td>14.28 (P=0.068)</td>
</tr>
<tr>
<td>2</td>
<td>6.42 (P=0.005)</td>
<td>13.11</td>
<td>8.33 (P=0.016)</td>
</tr>
<tr>
<td>3</td>
<td>3.83 (P=0.012)</td>
<td>9.22</td>
<td>5.83 (P=0.008)</td>
</tr>
<tr>
<td>4</td>
<td>2.54 (P=0.003)</td>
<td>8.80</td>
<td>4.45 (P=0.001)</td>
</tr>
</tbody>
</table>

Pain scores from the first seven days were averaged to make the first week score. After the first week, pain was scored once weekly for the following three weeks. The four weekly pain scores were averaged again to represent a monthly score. Univariate analysis of variance of between subjects effects were used to detect differences between the control groups and the groups that used the micro pulse vibration device (α=0.05)
Participants were assigned to comparison groups using a block allocation sequence which was concealed from the investigators. All subjects were given routine post treatment instructions and asked to complete a pain scale survey at appropriate intervals during the weeks after the separator or archwire appointment. The pain scale survey was in the format of a multi-page booklet that contained a series of 10-cm horizontal visual analog scales (VAS) on which the patient marked the degree of discomfort (none to worst pain imaginable) at the indicated time periods. The patients were instructed to make a mark on a new scale sheet at each time interval to record the perceived severity of pain in two categories: chewing/biting and overall pain. Patients using the AcceleDent® Aura micro pulse vibration device were instructed to mark the pain scales within one hour after using the device.

Patients had archwires placed and adjusted each month. Incidence and severity of pain was recorded by the patient after separator or archwire placement appointment daily for the first seven days after each monthly orthodontic appointment and then weekly for the remainder of the month for four months. The primary investigator monitored compliance regarding usage of the device via the integrated USB interface of the AcceleDent® Aura.

Patients in both groups were directed not to take any pain medication or analgesics, to include OTC medications and topical ointments. If “rescue” medication was needed for pain control of any kind the patient was instructed to indicate on the pain scale survey the date, time, dosage, reason and specific rescue medication taken. If rescue medication was not used on the day of or the day after adjustment, and if the patient did not take more than one dose of medication then the patient was allowed to remain in the study.

The hands-free micro pulse vibration device was used following manufacturer’s recommendations. Biting on the mouthpiece activated the device, and the vibration was transferred to the teeth. Patients assigned to the experimental group were instructed to use the device for 20 minutes daily beginning the day separators were placed and continued daily for the first four months of leveling and aligning.
Subjects were continuously reminded to complete their VAS and record pain scores and whether they were taking rescue medications. At the end of the four month trial patients returned the pain scale data to the PI. Univariate analysis of variance (ANOVA) of between subject effects were used to detect differences between the AcceleDent and Control groups ($\alpha = 0.05$).

**Results**

Average monthly pain scores were numerically generated from the patients’ VAS information and are reported in Table 1. In each group, twenty-nine of thirty-five subjects remained in the study after the four month trial. Six subjects from each group were excluded from the study. Four of six subjects from the device groups used a quantity of rescue medication that was considered excessive, mostly for non-dental pain. The other two subjects were non-compliant with their pain diary. In the control group, three subjects used rescue medication too often (headache, body pain) and three others were non-compliant with respect to the pain diary. Over the four month test period, repeated measures ANOVA detected significant differences between the micro pulse vibration device group and the control group for overall pain ($P = .002$) and for biting pain ($P = .003$) at $\alpha = .05$. From graphical data the authors also observed that perceived pain was highest at the beginning of the month, following archwire adjustment. Graphical representation of average overall pain scores for the device and control groups over the four month study period is shown in Figure 1. Graphical representation of average biting pain for the device and control groups over the four month study period is depicted in Figure 2. Stratified analysis was used for gender and age; however, the study was not powered adequately to look at subgroup differences. No harms or unintended effects were noticed. All subjects who were given a device reported that they were in less pain when using the device.

**Discussion**

Dental pain from orthodontic treatment provides pain researchers an excellent model to study. The pain is


relatively predictable from an intervention to a highly sensitive ligament apparatus surrounding the roots of the involved teeth. Researchers attribute initial and delayed pain responses following orthodontic treatment to compression and hyperalgesia of the periodontal ligament, respectively [13]. The periodontal ligament becomes sensitive to released substances such as histamine, bradykinin, prostaglandins, and serotonin [14]. These pain mediators are found in high levels when a pain response occurs. Given that pain is a subjective experience it is difficult to assess and few in vivo studies have measured and quantified it. Multiple studies found that pain after orthodontic procedures peaked at approximately 24 hours post treatment. Ngan et al. [1] and Scheurer et al. [1] found that pain increased 4 hours post-treatment and gradually returned to baseline levels at 7 days post-treatment; whereas Erdinç and Dinçer [15] found that pain was perceived at 2 hours and then decreased by day 3, with no difference found either between gender or size of the initial archwire. In our study, pain quickly increased and peaked at approximately 24 hours post-initial archwire or separator insertion. Figures 1 and 2 illustrate the differences in pain perception over the four month study period for device and control groups for overall and biting pain, respectively. Pain scores were higher throughout the course of treatment for biting pain. This agrees with the current concept that sustained PDL pressure from orthodontic adjustment decreases blood flow and recruitment of the pain producing substances over time [14]. Therefore, increasing blood flow to the PDL by vibratory stimulation at regular intervals may be effective in reducing the perception of orthodontic pain.

Blinding was not possible for this study and we cannot totally dismiss the possibility that a placebo effect from the device may have influenced the results. A sham device was not used in the current study for several reasons. First, possible skewed results could have occurred because a bite plate could essentially function as a bite wafer and secondly, a sham device could be interpreted as misleading or deceptive to the patient. Murdock et al. [16] found that plastic bite wafers chewed by the patient were as effective as over-the-counter pain medications after initial archwire placement. Hwang et al. [17] found that pain relief occurred in 56% of patients after using a bite wafer, however, the other 44% of the patients reported increased discomfort. In contrast, Otasevic et al. [18] found that their bite wafer group reported more pain than the group that avoided masticatory activity. Because of possible unwanted treatment effects of bite wafers on pain reporting, the authors chose not to use a sham device that may have a bite wafer effect.

Table 1 compared the pain data for the study groups and whether there were significant differences by month. The data reveal that for all groups except one there were significantly lower pain scores for the device group compared to the control groups for both overall pain and for biting pain. Only the first month data set for biting pain was not statistically different (P = .068). However, when repeated measures ANOVA was performed on all four months of data, significantly lower pain scores were recorded for overall pain and biting pain when the device was used. Gender and age data were collected, but there were not a sufficient number of subjects in these subjects to make any statistical conclusions.

Several authors have found that vibration will diminish pain responses [19, 20]. However, at least one study demonstrated no pain relief with the use of a vibratory device [21]. Vibration therapy in this randomized clinical trial resulted in significantly lower perceived pain and less OTC medication use. Vibration therapy has not been researched extensively in dentistry. A recent review of the literature in MEDLINE®/PubMed® revealed only 30 scholarly articles in the peer-reviewed literature using the search terms “dental pain” + “vibration therapy” [22]. The majority of research on vibration therapy in dentistry has studied the effect of vibration on dental anesthetic injections [23, 24]. In medicine, vibration therapy has been studied more extensively but still is not accepted as a first-line intervention [25, 26]. Zafar et al. [25] examined the current evidence regarding the effects of whole-body vibration in patients with osteoarthritis in a meta-analysis and found that vibration therapy reduces pain and improves function in patients with knee osteoarthritis. In another systematic literature review Collado-Mateo et al. [26] concluded that whole-body vibration could be an adequate treatment for fibromyalgia as a main therapy or added to a physical exercise program to improve balance, disability index, health-related quality of life, fatigue and pain. Results from this study and other studies in medicine suggest that vibration therapy holds promise in the reduction of pain for a variety of conditions. Based on the parameters of this randomized clinical trial, the use of a micro pulse vibration device significantly reduced the perception of overall and biting pain in patients undergoing orthodontic treatment.

Conflict of interests

The authors have declared that no conflict of interests exist.

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**Author contributions**

WD: analyzed and interpreted the data and drafted the manuscript. WL: was responsible for the design and manuscript primary draft of the original study from which this research highlight was written.

**References**