The Efficacy of Cold and Vibration Stimuli on Pain Perception During Administration of Local Anesthetic

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Introduction

Fear and anxiety related to dental injections are among the greatest barriers to care in pediatric dentistry.[1] Children with high dental fear are at double the risk of untreated dental caries, potentially negatively impacting overall oral health and quality of life. Several factors have been shown to influence pain perception during anesthetic administration, including needle gauge as well as anesthetic class, temperature and rate of delivery.[2,3] Research has also studied the effect of stimuli, such as cold and vibration, near the site of injection. This examines the interplay between the theories of distraction and gate control. The gate control theory explains that the perception of pain can be altered based on the sequence in which certain nerve fibers are activated. A-delta and C-type nerve fibers are responsible for transmission of "first pain" (i.e., pricking, sharp) and "second pain" (i.e., dull, aching, throbbing) signals, respectively. Their transmission to the CNS is relatively slower than that of A-beta fibers, which carry signals related to touch (i.e., vibrations, temperature). Thus, when vibration or cold is introduced before a pain-inducing stimulus (i.e., a needle), A-beta fibers are activated first, blocking or "closing the gate" of the later activated A-delta fibers. This decreases perceived pain. Vibration also stimulates mechanoreceptors in the skin and bone, further decreasing pain sensation near those areas.[4]

Most studies related to this topic have evaluated cold or vibration individually, with each demonstrating reductions in injection pain.[5, 6] However, limited research has examined the combined use of cold and vibration stimuli. Devices, such as Buzzy®, which provide simultaneous cold and vibration, have been used primarily for vaccines and intravenous injections but have been less studied in pediatric dental anesthesia.[7] Of the relatively few studies that have researched such devices for dental anesthetic administration, only some found a significant decrease in pain perception with most having generally conflicting results. [5-8] Further research is needed to better evaluate the effectiveness of combined cold and vibration stimuli in improving pain management during pediatric dental procedures.

Study Objectives

The aim of this research project is to determine whether simultaneous cold and vibration stimuli from the device Buzzy® can serve as a non-invasive method in decreasing pain perception of the pediatric patient during administration of local anesthetic. Long term, this research will provide dental professionals with an additional tool to use in the management of patient behavior during dental treatment requiring local anesthetic.

Methods

Using a randomized controlled crossover design, this study tested Buzzy®, a bug-shaped device in which the body of the "bug" vibrates while its wings are ice packs. Consent was obtained prior to subject participation.

Subjects

Healthy children ages 4-14 years (n = 25) who meet the inclusion and exclusion criteria (below) were subjects of this study.

Patient Selection

Inclusion Criteria: Children (ASA I, II) with previous positive behaviors (Frankl Behavior Rating score 3-4) and treatment plans consisting of restorative procedures requiring usage of local anesthetic. These procedures may include fillings (class I, II, III, IV, or V), stainless steel crown placement, pulpotomies, and extractions.

Exclusion Criteria: Children outside of the age range of 4-14 years old, with previous negative behaviors (Frankl Behavior Rating score 1-2, or needing nitrous during anesthetic delivery or sedation), and/or who do not need at least two visits of procedures requiring local anesthetic delivery. Patients should also not have any active, spontaneous pain at the time of the procedure.

Data Collection

Each participant underwent two dental visits: one under controlled conditions and the other under experimental. A coin was flipped for each patient to determine the order of the visits. The control intervention included bite block placement, application of 20% topical benzocaine for 30 sec prior to anesthetic delivery, and delivery (at 1 mL/ min) of local anesthetic via infiltration. No nitrous oxide was used. Conditions remained the same for the experimental protocol with the addition of the usage of Buzzy® before (30 sec), during, and after (30 sec) local anesthetic injection. The patient's heart rate at the beginning, middle, and towards the end of anesthetic delivery was collected using a pulse oximeter. At the completion of anesthetic delivery, the patient completed the Wong-Baker Faces Pain Rating Scale (WBFPRS). After the usage of Buzzy®, the patient's parent filled out a yes/no survey on whether they felt the device improved their child's experience during anesthetic delivery and if they would prefer its usage during a future visit.

Buzzy®

Statistical Analyses

The data collected was analyzed using paired t-tests and repeated measures ANOVA. This was from pulse oximeter readings and WBFPRS reports obtained from both control and experimental visits of 25 test subjects.

Results

Figure 1. Mean heart rate trends during procedure among the two groups

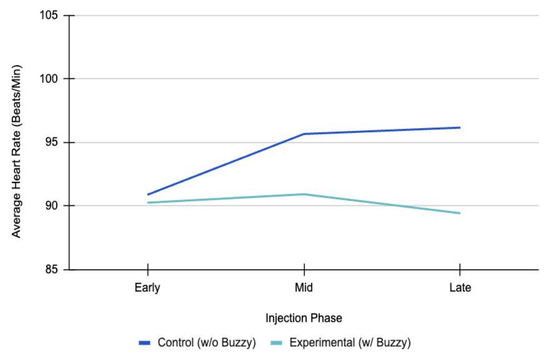
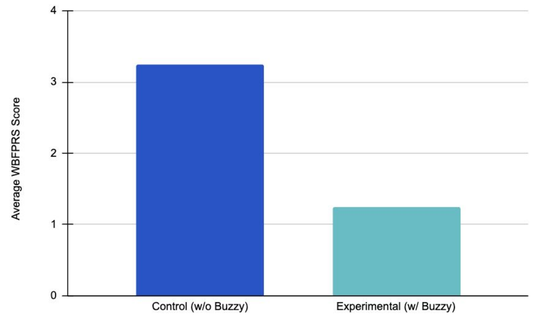


Figure 2. Mean value of Wong-Baker Faces Pain Rating Scale (WBFPRS) among the two groups



The patients in the control condition had a higher average heart rate (94.24 bpm) compared to those in the Buzzy® condition (90.19 bpm). This difference was statistically significant ($p<0.05$).

There was a significant change in heart rate over time and a significant difference between groups across time ($p<0.001$, $\varepsilon = 0.684$), with the Buzzy® group demonstrating lower and more stable heart rates during the procedure.

The intervention (Buzzy®) group had significantly lower pain scores on the WBFPRS than the control group ($p<0.001$), with a large effect size (Cohen's $d = 0.941$), indicating a clinically meaningful reduction in perceived pain.

100% of the parents surveyed felt Buzzy® improved their child's experience during anesthetic delivery and that they preferred its use at future visits. The majority of patients also positively engaged with the device, often naming it and requesting to take it home post-procedure.

Discussion and Conclusion

Use of devices, such as Buzzy®, appears to offer a meaningful adjunct to traditional behavior guidance by modulating both the sensory and emotional components of the injection experience. The significantly more regulated and decreased physiologic response over time observed in the intervention group in this study is consistent with a reduction in procedural arousal, which is particularly important in children who may already be predisposed to dental anxiety. When paired with their significantly lower self-reported discomfort, these findings suggest that combined cold and vibration can translate theoretical benefits of gate control and distraction into observable changes at the chairside.

The high level of acceptance among both parents and patients further underscores the clinical relevance of this approach. Parents' unanimous preference for continued use of the device, along with children's spontaneous engagement and affinity for it, indicates that Buzzy® is not only effective, but also well-aligned with a child-centered model of care. Such positive perceptions may enhance treatment acceptance, reduce anticipatory anxiety at subsequent visits, and support better continuity of care.

Taken together, these results support the integration of multimodal sensory devices into routine pediatric dental practice as a simple, non-invasive means of improving the injection experience. By operationalizing principles of neurosensory modulation and distraction in a practical format, Buzzy® may help clinicians better manage pain and anxiety without adding significant time or complexity to the appointment.

Study Limitations

- Small sample size
- Heart rate variability (influenced by patient age, baseline anxiety, past experiences)
- Subjective nature of WBFPRS, influenced by patient perception and emotional state
- Limited number of behavioral assessments used
- Potential inaccurate HR values from portable pulse oximeter if patients moved during procedure

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