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Evaluation of pain perception using a vibrating toothbrush during the administration of local anesthesia in children: A randomized clinical trial

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Highlights

The vibrating toothbrush operates based on the principles of the 'gate-control theory,' effectively reducing pain perception in children during the administration of local anesthesia.

This device provides a dual advantage by delivering both vibrotactile stimulation and audible distraction, enhancing its efficacy as a nonpharmacological pain management tool.

Preliminary findings suggest that the vibrating toothbrush is a reusable, cost-effective, and practical chairside method for improving the comfort of children during local anesthesia administration.

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Abstract

Aim: Effective pain management is a critical and challenging aspect of behavior management in children during dental procedures. Among nonpharmacological methods for achieving painless local anesthesia (LA), devices utilizing the vibrotactile method have shown promise. This study aimed to evaluate the effectiveness of a vibrating toothbrush in alleviating pain during the administration of an Inferior Alveolar Nerve Block (IANB) in children aged 6–11 years. **Methods:** A randomized clinical trial was conducted involving children aged 6–11 years requiring mandibular local anesthesia. Fifty-two participants were randomly assigned to two groups: Group 1 received topical anesthetic spray, and Group 2 used a vibrating toothbrush. Pain during injection was objectively assessed using the Sound Eye Motor (SEM) scale, while subjective pain after LA administration was evaluated using the Faces Pain Scale-Revised (FPS-R). Pain scores were compared between groups using the Mann-Whitney U test. **Results:** The mean FPS-R score for the topical anesthetic spray group was 4.26, compared to 2.53 for the vibrating toothbrush group, demonstrating a statistically significant difference (P = 0.03). The mean SEM score for the vibrating toothbrush group was lower (2.06) than that of the topical anesthetic spray group (1.66), though the difference was not statistically significant (P = 0.17). **Conclusions:** The vibrating toothbrush proved more effective in reducing pain compared to topical anesthetic spray during the administration of mandibular anesthesia in children.

Keywords: Anesthesia; Child; Electric Toothbrush; Pain Perception; Vibration

INTRODUCTION

Pain is the primary reason children seek dental care in developing countries, with most presentations in pediatric dentistry attributed to perioral pain, particularly acute toothache.[1] Providing painless treatment is a critical component of high-quality pediatric dental care.[2] In pediatric dentistry clinics, successful behavior management largely depends on effective pain control.[3] Local anesthesia is one of the most commonly employed methods for managing pain in children. However, its administration is often associated with discomfort and heightened anxiety in pediatric patients.[4]

Several techniques have been employed to reduce pain in children during the administration of local anesthesia. These include the application of topical anesthetics,[5] counter-stimulation,[6] buffering or pre-warming of the anesthetic solution,[7] pre-cooling of the injection site,[8] the use of local anesthesia patches,[9] and distraction methods such as relaxation techniques,[10] and WITAUL (writing in the air using legs).[11] The use of vibration as a pain-reducing strategy has also been extensively studied. Despite these efforts, no universally reliable painless injection technique has been identified. The application of topical anesthetics is the most widely used technique for managing and reducing needle insertion pain. However, their use is often limited by concerns regarding systemic toxicity, local irritation, and insufficient analgesic efficacy.[5]

Devices employing vibration have been effectively used to distract children and mitigate the pain associated with venipunctures and intramuscular injections.[12] Additionally, a study highlighted the innovative use of an electric toothbrush as a vibration device to reduce injection discomfort in children. The study demonstrated that vibration anesthesia during painful anesthetic procedures could be achieved by positioning the bristle side of the electric toothbrush over the injection site on the patient's skin.[13]

To date, only four studies have investigated the use of a vibrating toothbrush for pain reduction in children.[14–17] Therefore, the current study aimed to evaluate and compare the effectiveness of a vibrating toothbrush with a topical anesthetic spray in reducing pain during the administration of local anesthesia in children.

METHODS

This randomized clinical trial was conducted at the Department of Pediatric and Preventive Dentistry, adhering to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. Ethical approval was obtained from Institutional Ethical Committee of Narayana Dental College and Hospital: IEC/NDCH/2022/SEPT/P-79. The trial was registered in the Clinical Trials Registry of India (CTRI/2023/06/053350). Informed consent was obtained from the parents and/or guardians of all participants.

Sample Size Estimation

G power analysis was used to estimate a sample size with the large effect size of 0.80, an α error of 0.05, and the power of the study was kept at 80%. The total sample size achieved was 52 (26 per group).

Inclusion Criteria

The inclusion criteria for the study consisted of healthy children aged 6–11 years. Participants were required to need an Inferior Alveolar Nerve Block (IANB) injection for either primary or permanent mandibular teeth. Additionally, only children exhibiting positive or definitely positive behavior, as determined by the Frankl Behavior Rating Scale were included.

Exclusion Criteria

The exclusion criteria for the study included children with a known history of allergy to local anesthesia, those with special health care needs, and children presenting with dental emergencies such as trauma, acute pulpitis, dental abscesses, cysts, or pericoronitis.

A CONSORT diagram illustrating the flow of the study design is presented in Figure 1. A total of 75 eligible children were screened, of whom 52 met the inclusion criteria. These 52 children were then randomly allocated to either the control group (Group 1) or the intervention group (Group 2) in a 1:1 allocation ratio, with 26 children assigned to each group.

Randomization and Allocation

The randomization process was conducted using the chit method. A box was prepared containing 26 chits labeled as "Group 1" and 26 chits labeled as "Group 2." To minimize selection bias, the labeled chits were placed in opaque, sealed envelopes. Once a child consented to participate in the study, the investigator opened one of the sealed envelopes to determine the assigned treatment group. All procedures for both the intervention and control groups were performed by a single operator, a pediatric dentist. The investigator was responsible for both the randomization procedure and ensuring allocation concealment.

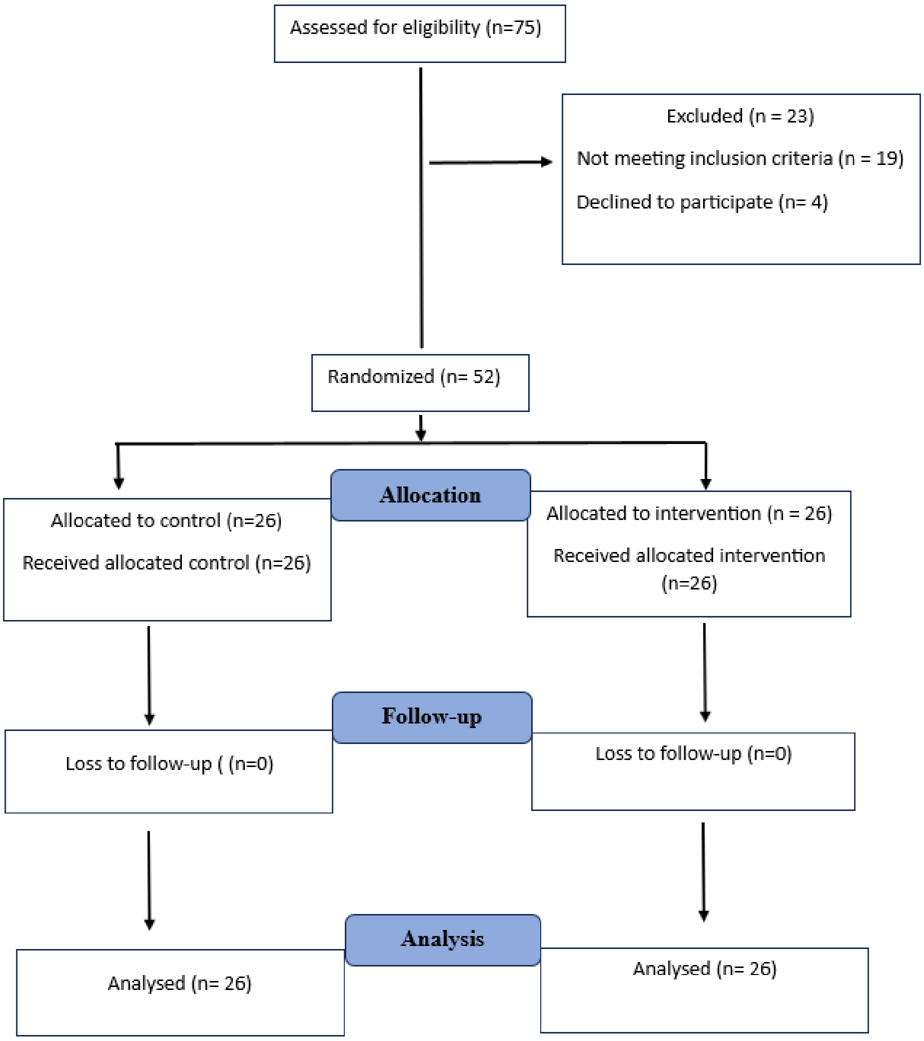

Figure 1. CONSORT flow diagram detailing the study design

Treatment/Clinical Procedure

Once a child was assigned to the appropriate group, the application site for topical anesthesia in the control group was isolated using a cotton roll and suction tip, then dried with sterile cotton gauze. A metered spray of lignocaine (Nummit spray, ICPA Health Products Ltd, Mumbai, India) was used to control the amount of topical anesthetic administered. The spray, delivering 7.5 mg of lignocaine per puff, was applied to the area from a distance of 1 to 2 cm. To standardize the procedure, a single puff of spray was used for each child. One minute after the application of the topical anesthetic, the mucosa was wiped clean with sterile cotton gauze.[20] Subsequently, 1.8 mL of 2% lidocaine with 1:100,000 epinephrine was administered to anesthetize the inferior alveolar and lingual nerves using a 27-gauge short needle (Figure 2).

Figure 2. Administration of topical anesthetic spray at the site of local anesthesia application

For the intervention group, a vibrating toothbrush (Colgate® Proclinical® Sonic Battery Powered Electric Toothbrush, Colgate-Palmolive, China) was positioned as close as possible to the injection site to stimulate the area of needle penetration. One minute later, 1.8 mL of 2% lidocaine was administered for the Inferior Alveolar Nerve Block (IANB) using a 27-gauge short needle (Figure 3). After administering the anesthesia, the needle was withdrawn, and the vibrating toothbrush remained in place for an additional 10 seconds to aid in the distribution of the anesthetic. The bristle side of the toothbrush was covered with a fruit wrap, which was replaced for each patient to ensure hygiene and prevent cross-contamination.

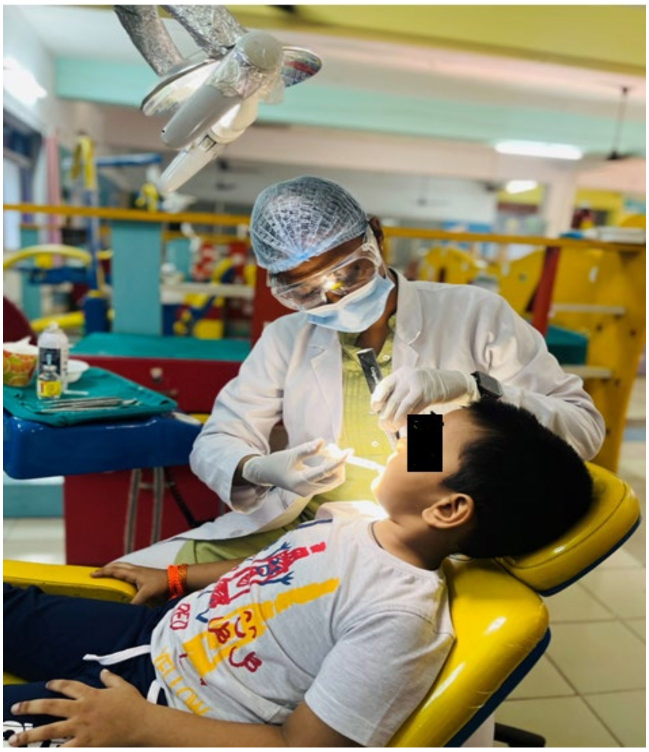

Figure 3. Application of the vibrating toothbrush at the injection site during local anesthesia administration

Pain Assessment

Objective pain assessment was conducted using the Sound, Eye, and Motor (SEM) scale[18] during the administration of the Inferior Alveolar Nerve Block (IANB). This scale is specifically designed to evaluate children's comfort or pain levels. Each observation (sound, eye response, and motor movement) was assigned a numerical value, and the average of these values represented the child's overall comfort or pain level at a given interval. The total SEM score ranges from 3 to 12, with higher scores indicating greater discomfort or pain.

During the administration of IANB, children's sounds, eye responses, and body movements were observed and scored by two blinded observers from a distance of 1.5 meters from the dental unit. These observers were trained in the scoring system prior to the study. Inter-examiner agreement was calculated using the weighted kappa statistic, yielding a value of 0.790, indicating a good level of agreement in SEM scale scoring.

Subjective evaluation of pain following the injection was performed using the FACES Pain Scale-Revised (FPS-R).[19] This scale features six cartoon faces displaying a range of expressions, from a smiling face (indicating no pain) to a tearful face (indicating the most severe pain). Each face is assigned a numerical value ranging from 0 to 10. Children were asked to indicate the face that best represented the level of pain they experienced during the injection. Following the pain assessment, the required dental treatment was carried out for each child.

Statistical Analysis

Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) software, version 20 (SPSS Inc., Chicago, Illinois, USA). An independent t-test and chi-square test were utilized to analyze demographic data, including age and gender distributions. The Mann-Whitney U test was employed to compare pain scores between the two groups.

RESULTS

The study included 24 male and 28 female participants.

In the control group, 38.5% (n = 10) were male and 61.5% (n = 16) were female, while the intervention group comprised 53.8% (n = 14) male and 46.2% (n = 12) female participants. The age distribution between the study groups showed no significant difference (P = 0.68), with a mean age of 8.66 ± 1.72 years in the intervention group and 8.93 ± 1.83 years in the control group. Similarly, no significant difference (P = 0.26) was observed in the gender distribution between the groups (Table 1).

Table 1. Comparison of age and gender distribution between the study groups

Demographic details	Group 1 (Control group) Mean ± SD	Group 2 (Vibrating toothbrush group) Mean ± SD	P-value
Age	8.93±1.83	8.66±1.72	0.68(NS)#
Gender	*n* (%)	*n* (%)	
Females	16(61.5)	12(46.20)	0.26(NS)^
Males	10(38.5)	14(53.80	

#: Independent t-test; ^: Chi-square test; NS: Non-Significant

Statistically nonsignificant differences (P = 0.175) were observed in the SEM scores between the two groups. However, the mean SEM score was lower for the vibrating toothbrush group (1.66) compared to the topical anesthetic group (2.06) (Table 2, Figure 4).

The FPS-R scores showed a statistically significant difference (P = 0.03) between the two groups. The mean score for the topical anesthetic group was 4.26, while the vibrating toothbrush group had a lower mean score of 2.53 (Table 3, Figure 5).

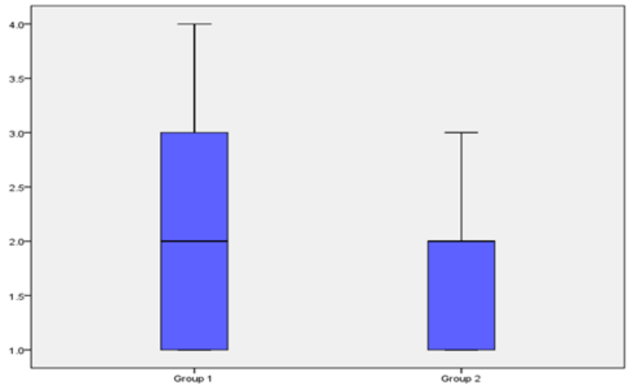

Figure 4. Intergroup comparison of Sound, Eye, and Motor scale scores between the study groups

Table 2. Intergroup comparison of Sound, Eye, and Motor scale scores between the study groups

Scale	Groups	Mean ± SD	Median	Interquartile range (IQR)	U value	P-value
Sound, Eye and Motor	Group 1 (Control group)	2.06 ± 0.96	2.00	2.00	82.00	0.17(NS)
	Group 2 (Vibrating toothbrush)	1.66 ± 0.63	2.00	1.00		

NS: Non-Significant

Table 3. Intergroup comparison of Faces Pain Scale-Revised scores between the study groups

Scale	Groups	Mean ± SD	Median	Interquartile range (IQR)	U value	P-value
Faces Pain Scale-Revised	Group 1 (Control group)	4.26 ± 2.12	4.00	4.00	64.00	0.03*
	Group 2 (Vibrating toothbrush group)	2.53 ± 1.76	2.00	2.00		

* Statistical significance at P < 0.05

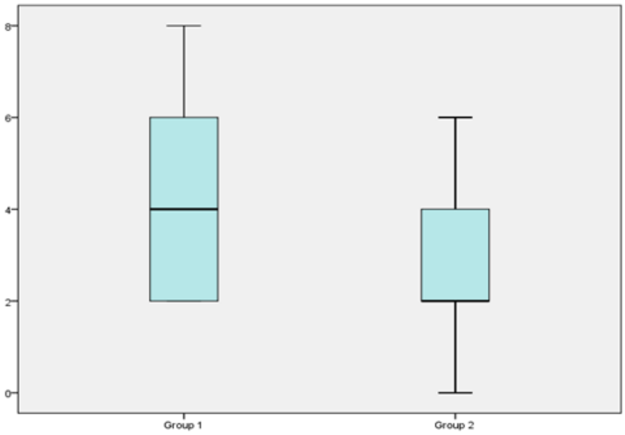

Figure 5. Intergroup comparison of Faces Pain Scale-Revised scores between the two groups

DISCUSSION

Pain control is a critical component in minimizing discomfort during the administration of local anesthetic solutions. Dentists should strive to reduce or eliminate this pain to the greatest extent possible.[21] Local anesthesia remains the most effective, safe, and well-established method for alleviating pain during dental procedures in children. However, while the primary objective of local anesthetic injections is to reduce pain in a targeted area, the process of needle insertion and the injection of the anesthetic solution can itself be painful due to associated anxiety and discomfort.[22]

Various methods are employed to minimize pain during the administration of local anesthesia, including the application of topical anesthesia, slow infiltration techniques, transcutaneous electrical nerve stimulation (TENS), computer-assisted local anesthesia devices (such as the Wand), and the use of vibration.[23]

Lignocaine spray, a widely used topical anesthetic, has a relatively weak surface anesthetic activity and a delayed onset of action, requiring approximately 112 seconds to take effect. For optimal efficacy, 1–2 minutes of contact with the mucosa is necessary. The water-and-oil emulsion in the spray enhances tissue penetration and access to nerve cells. However, its effectiveness can be limited by difficulty in confining the drug's action to a specific area, which reduces bioadhesion. Moreover, some individuals find the spray unpleasant, and it has been reported to cause difficulty swallowing in certain cases.[5]

Various new devices have been developed to address the limitations of topical anesthesia by leveraging the "gate-control theory" proposed by Melzack and Wall in 1965.[24] These devices, such as DentalVibe,[25] VibraJect,[26] and Accupal,[27] aim to reduce the pain associated with needle injections through the application of pressure, vibration, micro-oscillations, or a combination of these methods. The device used in the present study—a reusable, battery-operated electric toothbrush—applies the same principle. This vibrating toothbrush, which functions as both a source of vibration and a distraction, has the added benefit of being cost-effective. The mechanism is based on the gate-control theory, which posits that when nerve impulses evoked by tactile stimulation are transmitted through A-beta tactile fibers, they suppress the transmission of pain signals carried by A-delta and C nociceptive fibers at the secondary neuronal cell bodies in the dorsal horn.[28]

When vibration is used as a counter-stimulation during the administration of anesthesia, the tactile sensation reaches the brain before the pain sensation. As the brain can process only one sensation at a time, the initial tactile sensation is prioritized, effectively reducing the perception of pain.[29]

The current study aimed to evaluate and compare the effectiveness of the vibrating toothbrush against topical anesthetic spray in reducing pain during the administration of Inferior Alveolar Nerve Block (IANB) in children aged 6–11 years.

In this study, the intergroup comparison of mean pain scores using the SEM scale revealed a nonsignificant difference. However, the mean pain scores were lower in the vibrating toothbrush group compared to the control group. These findings align with those of Nameeda et al. [15], who reported that SEM scores were lower in children using an intraoral mucosal vibrator compared to a topical anesthetic gel and control group. Similarly, Tandon et al. [14] demonstrated that pain was significantly reduced in the intraoral mucosal vibrator group compared to the control group during the administration of an IANB. They attributed this reduction to the massaging effect of the vibration device, which helped dissipate the anesthetic solution and provided a soothing effect, addressing both the physiological and psychological aspects of patient management during local anesthesia administration.[15]

Dak-Alba et al.[30] also reported comparable findings, concluding that the use of vibration via the DentalVibe was more effective than topical benzocaine gel. They highlighted that the vibration technique served as a distraction, particularly for children who dislike flavored materials that might induce nausea. Additionally, they noted that the vibrating technique is a time-saving method compared to topical gel application, as it eliminates the need to dry the injection site.[30]

The results of the current study contradict the findings of Menni et al.,[31] who reported that the use of DentalVibe did not significantly reduce pain in children during the administration of local anesthesia. They noted that some children were reluctant to accept the DentalVibe, which was attributed to the vibratory sound produced by the device and the increased apprehension associated with introducing a new object into the oral cavity.[31]

The intergroup comparison of FPS-R scores revealed a statistically significant difference, with reduced pain observed in the vibrating toothbrush group compared to the control group. In this study, the reduction in pain may be attributed to the audible distraction provided by the sound produced by the vibrating device, as well as the early placement of the device at the injection site. This preconditioning likely helped reduce the perception of pain during local anesthesia administration.

These findings align with those of Shilpapriya et al. [32], who reported significantly lower mean pain scores during infiltration anesthesia of the maxilla and IANB of the mandible in children when DentalVibe was used compared to the control group. Similarly, Elbay et al. [33] demonstrated that pain was significantly reduced with DentalVibe compared to the traditional injection technique during the administration of IANB in children. Consistent results were also observed in a study by Painatt et al.,[34] who found that mucosal vibration was more effective in reducing pain than topical anesthetic spray in young adults.

Contrary to the above findings, a study conducted by Felemban et al. [35] reported that the use of DentalVibe did not significantly reduce pain and discomfort in children compared to the traditional injection technique. Similarly, Raslan et al. [36] observed that most children refused injections using DentalVibe, attributing this to the sound or sensation of the device, which might have provoked fear and anxiety in pediatric patients.

A limitation of the current study was the inability to blind the children due to the physical vibrational stimulation caused by the vibrating toothbrush, which could have influenced their perception and response.

CONCLUSIONS

Pain perception was reduced in the vibrating toothbrush group compared to the topical anesthetic spray group. These findings suggest that the vibrating toothbrush can be effectively used as an adjunct during the administration of local anesthesia for IANB in pediatric patients.

However, further research is needed with larger-scale randomized clinical trials to validate these findings. Additionally, future studies should compare the efficacy of the vibrating toothbrush with other vibrating devices to provide a comprehensive understanding of its relative effectiveness.

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