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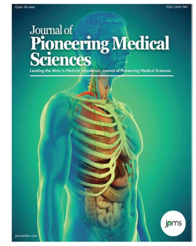

Auditory-Guided Vertical Brushing and Tooth Sensitivity: 12-Month Randomized Clinical Trial

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Abstract **Background:** Dentin hypersensitivity is frequently associated with improper toothbrushing techniques that result in cervical abrasion and dentin exposure. Although instruction in atraumatic brushing methods is routinely advised, long-term adherence remains inconsistent. It is hypothesized that real-time auditory feedback may enhance compliance with recommended brushing techniques. **Aim:** To evaluate and compare the long-term effectiveness of a modified toothbrush with auditory beat feedback and a conventional toothbrush-both following vertical brushing instruction-in reducing tooth sensitivity over a 12-month period. **Methods:** This assessor-blinded, randomized controlled clinical trial included 80 participants diagnosed with dentin hypersensitivity. Participants were randomly allocated into two groups. Group A used a conventional manual toothbrush and received standardized instruction in vertical brushing. Group B used a modified toothbrush with beat sound feedback in addition to the same vertical brushing instruction. Tooth sensitivity was evaluated using the Visual Analog Scale (VAS) and Schiff Sensitivity Scale at baseline, 1, 3, 6 and 12 months. Statistical analysis was performed using repeated-measures ANOVA and intergroup comparison tests. **Results:** Both groups demonstrated a reduction in tooth sensitivity over time. However, Group B exhibited a significantly greater and sustained reduction in VAS and Schiff sensitivity scores from 3 months onward ($p<0.05$). The improvement in Group B was maintained throughout the 12-month follow- up period. **Conclusion:** While instruction in vertical brushing alone resulted in measurable improvement, the addition of auditory feedback significantly enhanced long-term compliance and clinical outcomes. Themodified toothbrush demonstrated superior effectiveness in reducing dentin hypersensitivity over 12 months.

Key Words Dentin Hypersensitivity, Vertical Brushing, Auditory Feedback, Toothbrush Design, Behavioral Reinforcement

INTRODUCTION

Dentin hypersensitivity is characterized by a short, sharp pain arising from exposed dentin in response to thermal, tactile, osmotic or chemical stimuli, in the absence of any other dental pathology. Among the various etiological factors, improper tooth brushing technique-particularly aggressive horizontal brushing-is considered a primary contributor to cervical abrasion, gingival recession and dentin exposure. Clinical management strategies for dentin hypersensitivity traditionally include topical desensitizing agents, fluoride therapy and restorative interventions. Although effective to varying degrees, these approaches often address symptoms rather than the underlying mechanical cause. Consequently, patient education regarding atraumatic brushing techniques, especially vertical brushing, remains a cornerstone of preventive dentistry [1].

However, numerous studies have demonstrated that instruction alone does not reliably translate into sustained behavioral change. Patients often revert to habitual brushing patterns over time despite initial training. Recent advances in toothbrush design have therefore focused on incorporating sensory feedback mechanisms to facilitate consistent adherence to recommended brushing techniques. Auditory feedback, delivered as rhythmic beat sounds, has emerged as a promising tool to guide motor behavior in repetitive tasks. By providing real-time cues regarding brushing rhythm and direction, such devices may reduce reliance on cognitive recall and promote automatic habit formation. The present study aimed to evaluate the long-term effect of a modified toothbrush with auditory beat feedback on tooth sensitivity, compared to a conventional toothbrush, when both groups were instructed to follow vertical brushing techniques over a 12-month period [2].

Horizontal brushing is widely implicated in cervical abrasion and restoration breakdown. Vertical brushing, however, is less abrasive but requires guidance and compliance. A novel sound-guided toothbrush provides rhythmic auditory cues that encourage patients to adopt vertical brushing consistently. This study aimed to compare clinical wear and marginal adaptation of composite restorations in cervical abrasion lesions between conventional toothbrush users and sound-guided vertical toothbrush users over a 3-month period [3].

Dentin Hypersensitivity (DH) is a commonly encountered and challenging dental condition that often affects individuals between 20 and 50 years of age. The widely accepted hydrodynamic theory suggests that thermal, mechanical, chemical or osmotic stimuli cause fluid shifts within exposed dentinal tubules, leading to nerve activation and sharp, short-lasting pain. Accurate diagnosis relies on both visual inspection and standardized tactile. Anatomical and histological attributes of the cervical area, including thinning enamel near the CEJ, make this region more susceptible to damage. Cervical abrasion typically begins as a shallow, horizontal groove on the buccal or labial surface and presents a polished, shiny surface with tactile sensitivity upon examination [4]. Cervical abrasion is defined as a pathological process driven by repeated exposure to mechanical forces, including those from abrasive toothpaste or foreign objects habitually placed near the teeth. This condition, along with attrition and erosion, is classified under NCCLs and is often associated with discomfort, sensitivity or pulp involvement. It arises from multiple contributing factors, including forceful brushing, abrasive dentifrices and to a lesser extent, chemical erosion and occlusal stress.

Although the process typically unfolds gradually, it stimulates protective responses such as the formation of secondary and tertiary dentin or sclerotic dentin. If left unmanaged, cervical abrasion can lead to plaque accumulation, tooth sensitivity, pulpal inflammation or periodontal deterioration. Clinical management focuses on alleviating symptoms, restoring tooth structure and addressing associated soft tissue complications. The progression of cervical abrasion can be accelerated by a combination of biological, chemical and behavioral influences, with cementum and dentin being especially vulnerable. The lesions often present as wedge-shaped or V-shaped defects accompanied by gingival recession. Mechanical brushing habits-especially those involving vigorous technique or abrasive toothpaste-are recognized as primary contributors to abrasion. These lesions are more commonly seen in the incisor, canine and premolar regions compared to molars [5].

Non-Carious Cervical Lesions (NCCLs) represent a prevalent category of dental wear, commonly observed across diverse populations. These lesions encompass abrasion, abfraction and erosion. Abrasion results from mechanical forces unrelated to normal physiological actions such as mastication. The most frequent cause is improper use of toothbrushes and abrasive dentifrices, leading to wedge-shaped defects on exposed root surfaces. Abfraction is attributed to flexural stress from occlusal loading, whereas erosion involves the chemical dissolution of enamel and dentin in the absence of bacterial activity.

Cervical abrasion specifically results from external mechanical forces that repeatedly contact the tooth surface. Common contributing factors include aggressive brushing, the use of hard-bristled toothbrushes and abrasive toothpaste. Erosive agents that soften tooth structures further predispose them to mechanical damage [6].

One major limitation in effectively diagnosing and managing cervical abrasion is the lack of standardized clinical assessment tools. Several classification systems exist-such as those proposed by Eccles, Smith and Knight and Lussi-but their variability reduces comparability across studies. A more recent method, the Cervical Abrasion Index of Treatment Needs (CAITN) probe, was introduced to provide consistent lesion depth measurements and assist in treatment planning [7].

The prevalence of cervical abrasion varies depending on demographic and behavioral factors. Studies indicate a higher occurrence in older individuals and a notable link with brushing behaviors, particularly technique and bristle hardness. While no consistent gender difference shave been reported, the condition is commonly seen in posterior and maxillary teeth Adoption of standard indices like CAITN can help unify prevalence data and support evidence-based decision-making. From a management perspective, goals include halting lesion progression, reducing hypersensitivity, preventing pulpal damage and improving aesthetics. Patient education plays a critical role in prevention, including guidance on appropriate brushing force, brush type and toothpaste selection. For cases requiring restorative treatment, materials such as Resin-Modified Glass Ionomer Cements (RMGICs) and composite resins are commonly used. RMGICs, in particular, have shown greater retention in some cases, offering advantages in managing cervical lesions [8-9].

This review highlights the significant role of tooth brushing behaviors in the development of cervical abrasion. Horizontal brushing-especially when performed with excessive force-is consistently associated with greater tooth surface loss at the cervical margin.

METHODS

Study Design

This study was designed as a randomized, parallel-group, assessor-blinded controlled clinical trial with a 12-month follow-up period.

Study Setting and Ethical Approval

The study was conducted in the Department of Prosthodontics, [Institution Name], after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

Sample Size and Allocation

A total of 80 participants were recruited and randomly assigned into two equal groups (n = 40 per group) using a computer-generated randomization sequence:

- **Group A:** Conventional toothbrush with vertical brushing instruction
- **Group B:** Modified toothbrush with beat sound feedback and vertical brushing instruction

Inclusion Criteria

- Adults aged 18-55 years
- Presence of at least two teeth with clinically diagnosed dentin hypersensitivity
- Schiff sensitivity score ≥1
- Good general and oral health

Exclusion Criteria

- Active dental caries or cracked teeth
- Defective restorations in the cervical region
- Severe periodontal disease
- Use of desensitizing agents within the previous 3 months
- Orthodontic appliances or extensive prosthetic restorations
- Systemic conditions affecting pain perception

Intervention Protocol

Standardized Brushing Instruction (Both Groups): All participants received:

- Chairside demonstration of vertical brushing technique
- Verbal and written oral hygiene instructions
- Reinforcement of technique during follow-up visits

Group A: Conventional Toothbrush

Participants in Group A used a conventional manual toothbrush with soft bristles. Brushing technique relied on instruction-based compliance, requiring participants to consciously recall and self-regulate vertical brushing movements during daily oral hygiene practices.

Group B: Modified Toothbrush with Auditory Feedback

Participants in Group B used a modified toothbrush equipped with a beat sound mechanism. In addition to standardized vertical brushing instruction, participants were advised to synchronize brushing strokes with the auditory beat, which provided continuous real-time guidance regarding brushing rhythm and stroke direction.

The auditory feedback functioned as an external reinforcement mechanism during every brushing episode, reducing dependence on memory and voluntary control.

Outcome Measures

Primary Outcome: Tooth Sensitivity: Tooth sensitivity was assessed by a calibrated examiner blinded to group allocation using:

- Visual Analog Scale (VAS):
    - A 10 cm scale ranging from 0 (no pain) to 10 (severe pain)
- Schiff Sensitivity Scale:
    - No response
    - Mild response
    - Moderate response
    - Severe response

Evaluation Intervals

Assessments were conducted at:

- Baseline
- 1 month
- 3 months
- 6 months
- 12 months

Statistical Analysis

Data were analyzed using SPSS software (version XX):

- Intragroup comparisons were performed using repeated-measures ANOVA
- Intergroup comparisons were performed using independent t-tests
- Statistical significance was set at $p<0.05$

RESULTS

At baseline, no statistically significant differences were observed between Group A and Group B in mean VAS or Schiff sensitivity scores ($p>0.05$).

Both groups demonstrated a progressive reduction in tooth sensitivity over the 12-month period, indicating that vertical brushing instruction alone has a beneficial effect. However, Group B exhibited a significantly greater reduction in both VAS and Schiff sensitivity scores from the 3 month follow-up onward ($p<0.05$).

The improvement observed in Group B was sustained at 6 and 12 months, whereas Group A showed a comparatively gradual and less pronounced reduction. No adverse events or device-related complications were reported (Table 1-3).

Statistical Analysis

- Intergroup comparison showed statistically significant differences from 3 months onward ($p<0.05$)
- Group B showed a significantly greater reduction in Schiff sensitivity scores at 3, 6 and 12 months ($p<0.05$)

Interpretation

Auditory-guided brushing resulted in significantly greater reduction in dentin hypersensitivity compared to instruction alone.

Figure 1 shows line graph showing changes in Mean Vas scores over 12 months.

The graph depicts a progressive reduction in VAS scores in both groups over time. Group B demonstrates a steeper and sustained decline compared to Group A, indicating superior long-term reduction in tooth sensitivity when auditory feedback is used.

Line graph showing the change in mean Visual Analog Scale (VAS) scores for tooth sensitivity over a 12 month period in both groups. Although both groups demonstrated a

Table 1: Mean Visual Analog Scale (VAS) Scores at Different Time Intervals

Time Interval	Group A: Conventional Toothbrush (Mean±SD)	Group B: Modified Toothbrush with Auditory Feedback (Mean±SD)
Baseline	6.8±0.7	6.9±0.6
1 Month	6.2±0.6	5.4±0.5
3 Months	5.6±0.5	4.2±0.4
6 Months	5.1±0.4	3.1±0.3
12 Months	4.7±0.4	2.3±0.3

Table 2: Mean Schiff Sensitivity Scores at Different Time Intervals

Time Interval	Group A: Conventional Toothbrush (Mean±SD)	Group B: Modified Toothbrush with Auditory Feedback (Mean±SD)
Baseline	2.5±0.4	2.6±0.4
1 Month	2.3±0.3	2.0±0.3
3 Months	2.0±0.3	1.4±0.2
6 Months	1.8±0.2	0.9±0.2
12 Months	1.6±0.2	0.6±0.1

Table 3: Intergroup Comparison of Tooth Sensitivity Reduction at 12 Months

Parameter	Group A	Group B	p-value
Mean VAS reduction	2.1	4.6	<0.001
Mean Schiff score reduction	0.9	2.0	<0.001

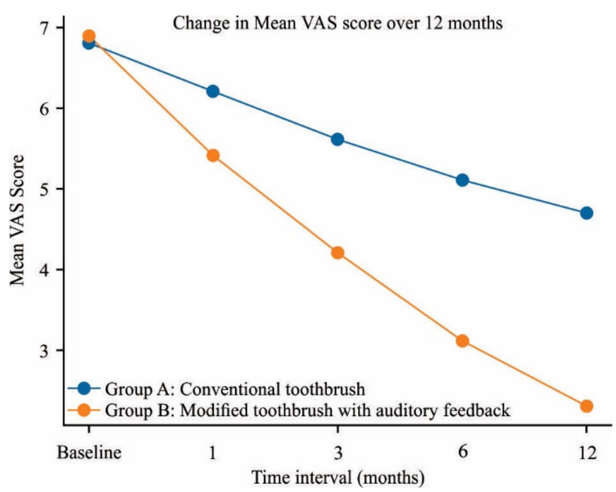

Figure 1: Change in Mean VAS Scores Over 12 Months

X-axis: Time intervals (Baseline, 1, 3, 6, 12 months), Y-axis: Mean VAS score, Line 1: Group A: Conventional toothbrush (instruction-based vertical brushing), Line 2: Group B: Modified toothbrush with auditory feedback

reduction in sensitivity following instruction in vertical brushing, Group B (modified toothbrush with auditory feedback) exhibited a significantly greater and sustained reduction from 3 months onward compared to Group A.

Figure 2 show line graph showing changes in Mean schiff sensitivity scores over 12 months.

Group B shows a marked and continuous reduction in Schiff sensitivity scores compared to Group A, reflecting enhanced compliance and effectiveness of auditory-guided vertical brushing.

Line graph illustrating the change in mean Schiff sensitivity scores over the 12-month follow-up period. Group B demonstrated a steeper decline and lower final sensitivity scores compared to Group A, indicating improved long-term compliance and effectiveness of auditory-guided vertical brushing.

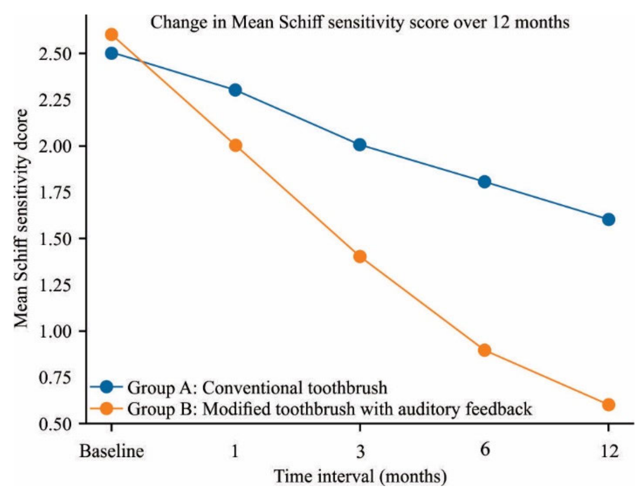

Figure 2: Change in Mean Schiff Sensitivity Scores Over 12 Months

Line graph illustrating the change in mean Schiff sensitivity scores over the 12-month follow-up period. Group B demonstrated a steeper decline and lower final sensitivity scores compared to Group A, indicating improved long-term compliance and effectiveness of auditory-guided vertical brushing

Enrollment

- Assessed for eligibility (n = 96)
- Excluded (n = 16)
    - Not meeting inclusion criteria (n = 10)
    - Declined to participate (n = 4)
    - Other reasons (n = 2)

Randomization

Randomized (n = 80)

Allocation

Group A: Conventional Toothbrush with Vertical Brushing Instruction (n = 40):

- Allocated to intervention (n = 40)
- Received allocated intervention (n = 40)
- Did not receive allocated intervention (n = 0)

Group B: Modified Toothbrush with Auditory Feedback+Vertical Brushing Instruction (n = 40)

- Allocated to intervention (n = 40)
- Received allocated intervention (n = 40)
- Did not receive allocated intervention (n = 0)

Follow-Up
Group A:

- Lost to follow-up at 3 months (n = 2)
- Lost to follow-up at 6 months (n = 3)
- Lost to follow-up at 12 months (n = 3)
- Total lost to follow-up (n = 8)

Group B:

- Lost to follow-up at 3 months (n = 1)
- Lost to follow-up at 6 months (n = 2)
- Lost to follow-up at 12 months (n = 2)
- Total lost to follow-up (n = 5)

Analysis
Group A:

- Analyzed (n = 32)
- Excluded from analysis (n = 8)
- Reason: Loss to follow-up

Group B:

- Analyzed (n = 35)
- Excluded from analysis (n = 5)
- Reason: Loss to follow-up

DISCUSSION

The present study demonstrates that while instruction in vertical brushing is effective in reducing dentin hypersensitivity, auditory-guided reinforcement significantly enhances long-term outcomes. Both groups received identical brushing instructions, thereby isolating the effect of auditory feedback. The superior performance of Group B suggests that the difference in outcomes was not due to knowledge acquisition but rather consistent behavioral execution [10].

Instruction-based brushing relies heavily on cognitive recall and voluntary compliance, which are known to diminish over time. In contrast, the auditory feedback provided in Group B served as a real-time motor guidance system, facilitating rhythm, stroke direction and controlled brushing force. This reduced inadvertent horizontal movements and excessive cervical stress [11].

From a behavioral dentistry perspective, auditory cues promote habit formation by shifting brushing from a consciously regulated activity to an automatically guided behavior. This mechanism likely accounts for the sustained reduction in tooth sensitivity observed at 12 months. the modified Bass technique, which employs angled, gentle vibratory strokes, is protective and less likely to cause trauma. Electric toothbrushes equipped with pressure sensors are a promising preventive tool, as they regulate force and are particularly helpful for individuals with limited manual dexterity or aggressive habits. Brushing frequency and duration also influence abrasion risk; more than twice-daily brushing or prolonged brushing sessions amplify cumulative stress. Encouraging patients to limit brushing sessions to two minutes and apply gentle pressure is essential for reducing damage [12,13]

The studies reviewed showed considerable variation in methodology, follow-up period and sample size, which limits the generalizability of findings. To improve the quality of evidence, future research should implement standardized diagnostic tools and extend follow-up durations. It is also critical to study the combined influence of toothpaste abrasivity, brushing methods and toothbrush types. A toothbrush was successfully developed using a natural composite filament made from neem fiber, neem powder and PLA. Analysis of its functional groups, crystalline structure and morphology revealed that the neem-infused bristles help reduce oral diseases and improve teeth whitening. FTIR results showed peaks linked to cellulose, carbohydrates and nimbin-an active compound known for its oral health benefits. The high amorphous content (89%) suggests reduced crystallinity, supporting the natural antibacterial properties of neem. This eco-friendly toothbrush blends modern dental care with neem's natural antimicrobial effects, offering promising benefits for oral health and sustainability [15].

Toothbrush may be a well-known tool in oral care. Familiarity of youngsters with this device is vital. Effective tooth brushing aids in the management of cavity and periodontitis. Dentists and Dental assistants need adequate information about children's oral hygiene to teach them and their parents. Also tooth brushing twice daily under parent's supervision is suggested.

The oldest tooth brushing method was described in 1913 by Fones and is suggested mainly for youngsters. The Bass technique places emphasis on the removal of plaque from above and slightly below the gingival margin. Bass had been changed to the Modified Bass where the bristle position and predominantly horizontal brush movements within the Bass method are retained but vertical and sweeping motions to make circles are added. The Stillman technique is analogous to the Bass technique. The vertical motions of the Stillman technique could also be combined with the Bass, as prescribed for the Modified Bass. Charters suggested angling the comb head at 45° coronaly to the margin instead of apically. Vibratory and slight rotary movement is then applied before moving to the subsequent group of teeth. An abnormal frenum may be an additive factor to plaque accumulation and may cause inhibition to proper tooth brushing. The Scrub technique is the most simple technique, with the toothbrush held parallel to the gingiva and horizontal motions to scrub the gingival crevice in an ordered fashion. There are some modification techniques such as Hirschfeld's technique which is a modification of the Fone's technique where the circular motion is smaller and concentrated over the gingival crevice. Frequency and duration of brushing are usually included with recommendations concerning the tactic of tooth brushing for children [16].

Modified Bass technique emerged as the most commonly recommended brushing method for patients aged 13-17 years. Oral hygiene instructions should be tailored to align with a child's developmental level and motor coordination. It is important to account for differences in brushing ability, particularly among younger children.

Fones technique emerged as the most commonly recommended brushing method by dentists for children aged 6-12 years, regardless of gender. The Modified Bass technique was the next most preferred. Ensuring proper oral hygiene during the mixed dentition stage is crucial and demands ongoing reinforcement. Participants who regularly used ultrasonic toothbrushes showed a noticeable reduction in oral and salivary bacterial counts compared to those in the control group. However, proper guidance and monitoring are essential for individuals using ultrasonic toothbrushes.

A toothbrush is a principle instrument that helps in maintaining proper hygiene and oral care. Based on the different bristle diameters the tooth brushes have been categorized as soft (0.2 mm), medium (0.3 mm) and hard (0.4 mm). Choosing the right toothbrush plays an important role in maintaining oral hygiene. Apart from choosing the right toothbrush, proper usage of the toothbrush should also be taken into consideration, as improper brushing may lead to the soft and hard tissues of the teeth. This may lead to conditions such like abrasion. Abrasion is the process in which the enamel erodes due to the force applied on teeth, improper brushing can also be caused for abrasion . Tooth brushes with different functions have been developed for oral health management. The factors that influence the surface roughness of teeth are the brushing methods, frequency, duration of brushing, bristle diameter, shape, force of brushing direction of brushing, number of bristles per tuft and its management.

Clinical Significance

- Demonstrates limitations of instruction-only oral hygiene education
- Supports the role of sensory feedback in behavioral modification
- Offers a non-pharmacological, preventive approach to managing dentin hypersensitivity

CONCLUSIONS

Within the limitations of this study, it can be concluded that while vertical brushing instructional one reduces dentin hypersensitivity, the incorporation of auditory feedback through a modified toothbrush provides significantly greater and sustained clinical benefits. Continuous sensory reinforcement appears to play a crucial role in maintaining proper brushing behavior over time.

Future Scope

- Longitudinal imaging studies (SEM or profilometry)
- Evaluation in geriatric and high-risk populations
- Combination with desensitizing dentifrices

Limitations

- Reliance on patient compliance despite reinforcement
- Single-center study design
- Lack of imaging modalities to directly assess cervical abrasion

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Ethical Statement and Consent to Participate

The study protocol was reviewed and approved by the saveetha Dental college and Hospital IHEC/SDC/PHD/PROSTHO-2426/25/TH-007 Written informed consent to participate was obtained from all participants prior to enrollment in the study. For participants under 18 years of age, consent was obtained from a parent or legal guardian.

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