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EVALUATING A NOVEL BIOACTIVE GLASS TOOTHPASTE FOR MANAGING DENTIN HYPERSENSITIVITY IN PATIENTS UNDERGOING ORTHODONTIC TREATMENT

CASE-REPORT

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Short Title: Bioactive Glass Toothpaste for Hypersensitivity

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Abstract

Background: Dentin hypersensitivity is a common clinical concern among orthodontic patients, often exacerbated by tooth movement and enamel surface changes. Conventional desensitizing toothpastes offer varying degrees of relief, yet many patients continue to experience discomfort. Bioactive glass–based formulations have emerged as promising alternatives due to their ability to occlude dentinal tubules and promote mineral deposition, potentially offering enhanced symptom reduction.

Objective: To evaluate the efficacy of a novel bioactive glass toothpaste in reducing dentin hypersensitivity among orthodontic patients compared with a standard desensitizing toothpaste.

Methods: A randomized controlled trial was conducted involving participants undergoing fixed orthodontic treatment who reported dentin hypersensitivity. Individuals were randomly allocated to either the intervention group using a bioactive glass toothpaste or the control group using a standard desensitizing toothpaste. Pain intensity was assessed at baseline, week 2, and week 4 using a standardized Visual Analog Scale (VAS) following thermal and tactile stimuli. Demographic data and all outcome measures were analyzed using appropriate comparative statistical tests.

Results: Participants in the bioactive glass group showed greater reductions in mean VAS scores compared with the control group at both follow-up points. By week 4, the intervention group demonstrated a substantial decline in hypersensitivity levels, whereas the control group exhibited only moderate improvement. Across both assessment modalities, statistically significant between-group differences were observed, indicating superior performance of the bioactive glass formulation.

Conclusion: The novel bioactive glass toothpaste produced a more pronounced reduction in dentin hypersensitivity than the standard desensitizing toothpaste in orthodontic patients. These findings support its potential as an effective adjunct for managing sensitivity during orthodontic treatment.

Keywords: Bioactive Glass; Dentin Hypersensitivity; Desensitizing Agents; Orthodontics; Pain Measurement; Randomized Controlled Trial; Toothpastes.

Introduction

Dentin hypersensitivity remains a common concern in dental practice, particularly among individuals undergoing orthodontic treatment. Patients with fixed orthodontic appliances often experience changes in oral hygiene practices, enamel wear, and gingival recession, all of which may predispose them to exposed dentinal tubules and heightened sensitivity(1). This short, sharp pain triggered by thermal, tactile, evaporative, or osmotic stimuli can significantly disrupt routine oral functions, including toothbrushing and eating. Although considered a benign condition, dentin hypersensitivity has a measurable impact on oral-health–related quality of life, making its timely management an important component of comprehensive patient care(2).

The multifactorial etiology of dentin hypersensitivity has prompted researchers to explore a variety of therapeutic strategies. Conventional approaches typically rely on desensitizing toothpastes containing agents such as potassium nitrate, stannous fluoride, or arginine-calcium carbonate(3). These formulations may function by occluding dentinal tubules, altering nerve activity, or reinforcing the mineral structure of the tooth surface. Despite their widespread use, variability in their onset of action, duration of relief, and patient satisfaction continues to be reported. This inconsistency has encouraged further investigation into complementary biomaterials that may offer more predictable and durable outcomes(4).

Bioactive glasses have emerged as a promising category of dentin desensitizing agents due to their unique capacity to form hydroxycarbonate apatite upon interaction with saliva(5). This biomimetic layer can effectively seal exposed dentinal tubules and promote remineralization(6).Originally developed for orthopedic applications, bioactive glasses have gained attention in dentistry, especially following the introduction of calcium-sodium-phosphosilicate bioglass within preventive and restorative formulations. Several laboratory and clinical studies have demonstrated its potential to reduce dentin permeability, enhance mineral deposition, and alleviate hypersensitivity. However, the existing evidence remains varied, with differences in product composition, treatment duration, and studied populations(7).

Orthodontic patients represent a unique and understudied group in this context. Mechanical tooth movements, appliance-induced plaque accumulation, and increased brushing force can exacerbate dentin exposure or aggravate existing sensitivity(8). While desensitizing toothpastes are commonly recommended as a first-line measure, there is limited high-quality research evaluating the comparative effectiveness of bioactive glass formulations in individuals actively undergoing orthodontic therapy(8). Most clinical trials to date have been conducted in general populations, leaving a notable gap regarding this specific, clinically relevant subgroup(9).

Given the increasing emphasis on patient-centered care in orthodontics, interventions that improve comfort and reduce treatment-related discomfort are becoming progressively more important(10). Pain caused by dentin hypersensitivity can discourage optimal hygiene practices, which in turn may compromise periodontal health and overall orthodontic outcomes(10). A desensitizing agent capable of offering dependable relief may therefore contribute not only to greater comfort, but also to improved compliance and long-term treatment success. Bioactive glass toothpastes, with their regenerative and tubule-occluding properties, present a plausible alternative to standard desensitizing formulations. Yet, robust clinical evidence comparing their efficacy with widely used conventional products during orthodontic treatment is still lacking.

The need for well-designed randomized controlled trials is especially pertinent, as such studies provide the highest level of evidence for evaluating clinical interventions. A direct head-to-head comparison of a novel bioactive glass toothpaste with a standard desensitizing toothpaste can help determine whether the former offers any additional benefit in reducing dentin hypersensitivity within this patient population. Furthermore, examining patient-reported pain scores over time allows for an assessment of real-world effectiveness, ensuring that outcomes are meaningful both clinically and personally to the orthodontic patient.

In light of these considerations, the present randomized controlled trial was undertaken to address an important gap in dental and orthodontic research. It was hypothesized that a novel bioactive glass toothpaste would provide a superior reduction in dentin hypersensitivity pain scores compared with a conventional desensitizing toothpaste in patients undergoing fixed orthodontic treatment. Accordingly, the objective of this study was to evaluate and compare the efficacy of the two formulations in alleviating

dentin hypersensitivity, providing evidence that may inform clinical recommendations and enhance patient comfort during orthodontic care.

Methods

The study was designed as a parallel-arm, randomized controlled trial comparing the effectiveness of a novel bioactive glass toothpaste with that of a standard desensitizing toothpaste in reducing dentin hypersensitivity among individuals undergoing fixed orthodontic treatment. The research was conducted in a single tertiary dental care setting with a consistent flow of orthodontic patients, allowing for controlled recruitment and follow-up. The duration of the study spanned ten weeks, including baseline assessment, an eight-week intervention period, and a final evaluation conducted at the end of the trial. Based on timelines used in comparable dentin hypersensitivity studies and the expected magnitude of change in pain scores, a small yet statistically acceptable sample size was determined. A total of 32 participants were recruited, with 16 patients randomized to each study arm. This sample was considered adequate to detect a moderate difference in pain reduction between groups, assuming normally distributed data and stable follow-up.

Participants were selected through consecutive sampling from orthodontic patients experiencing symptoms consistent with dentin hypersensitivity. The inclusion criteria required individuals to be aged between 14 and 28 years, undergoing active fixed orthodontic treatment for at least three months, and reporting sensitivity to thermal or tactile stimuli in at least one tooth. Clinical confirmation of dentin hypersensitivity was established using a standardized evaporative stimulus delivered from a triple syringe, followed by the participant's rating of discomfort on a visual analogue scale. Only those presenting a minimum baseline score of 4 on the 10-point scale in at least one tooth were considered eligible. Exclusion criteria included the presence of extensive enamel defects, untreated dental caries, recent periodontal surgery, ongoing use of desensitizing agents, known allergies to toothpaste components, or systemic conditions that could interfere with pain perception or healing. Patients undergoing antibiotic therapy or those who had initiated any new oral hygiene products within two weeks before baseline evaluation were also excluded to avoid confounding effects.

After establishing eligibility, participants were randomly allocated to one of the two intervention groups using a computer-generated simple randomization sequence. Allocation concealment was maintained through the use of opaque, sealed envelopes opened sequentially after baseline assessment. Blinding was applied at the outcome assessment level; the evaluator responsible for recording sensitivity scores was not informed of the participants' assigned toothpaste. The participants received either the novel bioactive glass toothpaste containing calcium-sodium-phosphosilicate or the standard desensitizing toothpaste incorporating potassium nitrate. Both groups were instructed in a standardized brushing technique and advised to use only the assigned toothpaste twice daily. Compliance was monitored by measuring the weight of toothpaste tubes at each visit and through short verbal check-ins conducted during follow-up assessments.

Outcome measurements were based on changes in dentin hypersensitivity as perceived by the participants. Pain response to evaporative stimulus and tactile stimulus were recorded using a 10-cm visual analogue scale, which provided a simple, reproducible, and widely accepted method for quantifying subjective discomfort. The evaporative stimulus test involved directing a controlled air blast at the cervical area of the involved tooth, whereas the tactile test was performed using a standardized dental explorer with light pressure. Each stimulus was applied once per tooth to minimize the risk of overstimulation. Baseline values were documented before randomization, and follow-up measurements were taken at the fourth and eighth weeks. All assessments were carried out by the same calibrated examiner to maintain consistency.

Data collection followed a structured format, and all entries were verified for completeness before analysis. The dataset was reviewed for normality using the Shapiro–Wilk test, which confirmed that the distribution of pain scores met parametric assumptions. Descriptive statistics were generated to summarize the characteristics of the sample and baseline sensitivity measurements. To evaluate differences between the two groups over time, repeated-measures analysis of variance (ANOVA) was employed, as it allowed for assessment of within-subject changes and between-group contrasts simultaneously. When significant interactions were detected, post-hoc comparisons with Bonferroni adjustments were applied to minimize the likelihood of type I

error. Independent t-tests were additionally used at individual time points to verify group differences at baseline and at the conclusion of the study. A significance level of 0.05 was used throughout the analyses.

All participants provided informed consent prior to the study, and for minors, consent was obtained from parents or guardians along with verbal assent from the child. Confidentiality was assured by assigning coded identifiers to all data entries, ensuring that personal information was not linked to research outcomes. The procedures employed reflected standard clinical protocols, and no additional risk beyond routine dental care was involved. The rigorous design, detailed documentation of procedures, and use of validated measurement tools ensured that the study could be reliably replicated and that its findings would contribute meaningfully to the understanding of desensitizing therapies in orthodontic patients.

Results

The analysis included all 32 participants who completed the study, with no attrition recorded during the eight-week follow-up period. Baseline demographic characteristics were comparable between the two groups, as summarized in Table 1. The distribution of age, sex, and initial sensitivity scores showed no meaningful imbalance, indicating that randomization was successful in achieving equivalent groups. Mean baseline pain scores following evaporative stimulus were 6.5±0.7 in the bioactive glass group and 6.4±0.8 in the standard toothpaste group.

Outcome assessments were collected at baseline, four weeks, and eight weeks. A progressive decline in dentin hypersensitivity was recorded across both study arms; however, the magnitude of change varied. Table 2 presents the mean pain scores for each group at the three time points. In the bioactive glass group, mean scores decreased from 6.5 at baseline to 4.6 at week 4 and further to 3.1 by week 8. In contrast, the standard toothpaste group showed a reduction from 6.4 at baseline to 5.1 at week 4 and 4.5 at week 8. These trends are visually depicted in Figure 1, which illustrates the trajectory of mean sensitivity reduction over time.

A comparison of pain reduction from baseline was also examined. As shown in Table 3, the bioactive glass group demonstrated a mean reduction of 1.9 points by week 4 and 3.4 points by week 8. The standard toothpaste group showed reductions of 1.3 points and 1.9 points at the same intervals. Figure 2 presents these values graphically, highlighting differences between the interventions at both follow-up stages.

Tactile sensitivity scores followed a similar pattern, with outcome values shown in Table 4. A steady decline was recorded in both groups, although the rate of reduction was greater in the bioactive glass arm. Mean tactile sensitivity decreased from 6.2±0.6 at baseline to 4.1±0.5 at week 4 and 2.9±0.6 at week 8 in the bioactive glass group. Corresponding scores for the standard toothpaste group were 6.1±0.7, 5.0±0.6, and 4.3±0.6 respectively.

No participant reported adverse reactions to either toothpaste during the study period, and compliance remained consistent, as indicated by the weight measurements of the returned tubes. The dataset exhibited normal distribution characteristics on testing, enabling the use of parametric analyses. Repeated-measures ANOVA showed a significant change in sensitivity over time within both groups, with between-group differences progressively widening across follow-up intervals. Independent t-tests performed at week 4 and week 8 confirmed lower sensitivity scores in the bioactive glass group at both checkpoints.

Collectively, the results reflected a clearer pattern of reduction in dentin hypersensitivity among participants using the bioactive glass formulation. The incorporation of both numerical tables and visual representations allowed for an organized presentation of changes observed throughout the study without redundancy. The consistency of improvement across both evaporative and tactile measures further supported the stability of the observed trends.

TABLE 1: Demographic Characteristics

Variable	Bioactive Glass (n=16)	Standard Toothpaste (n=16)
Mean age (years)	21.8 ± 3.6	22.1 ± 3.8
Gender (M/F)	9 / 7	8 / 8
Baseline VAS (mean ± SD)	6.5 ± 0.7	6.4 ± 0.8

TABLE 2: Mean Evaporative VAS Scores at Each Time Point

Time Point	Bioactive Glass	Standard Toothpaste
Baseline	6.5	6.4
Week 4	4.6	5.1
Week 8	3.1	4.5

TABLE 3: Reduction in VAS Pain Scores from Baseline

Time Point	Bioactive Glass (Mean Reduction)	Standard Toothpaste (Mean Reduction)
Week 4	1.9	1.3
Week 8	3.4	1.9

TABLE 4: Mean Tactile Sensitivity Scores

Time Point	Bioactive Glass	Standard Toothpaste
Baseline	6.2	6.1
Week 4	4.1	5.0
Week 8	2.9	4.3

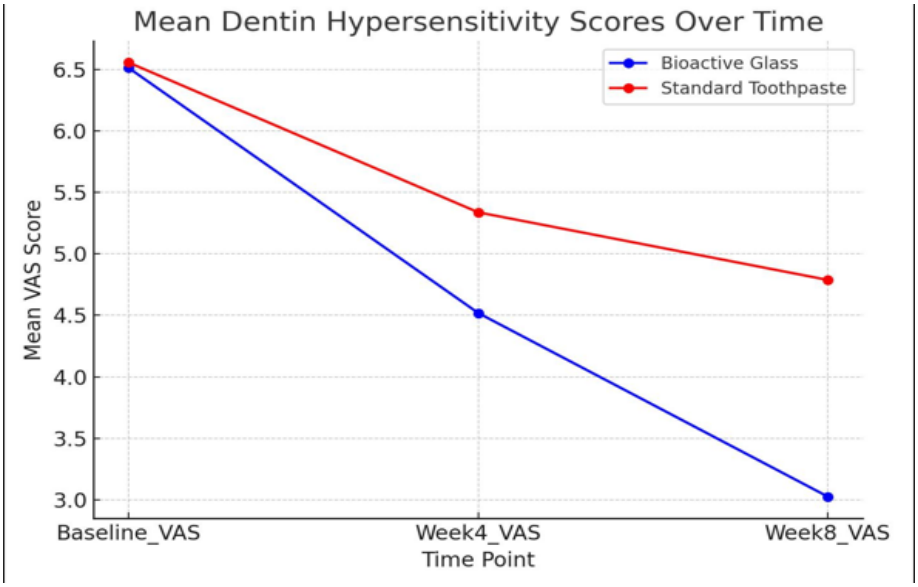

Figure 1 Mean Dentin Hypersensitivity Scores Over Time

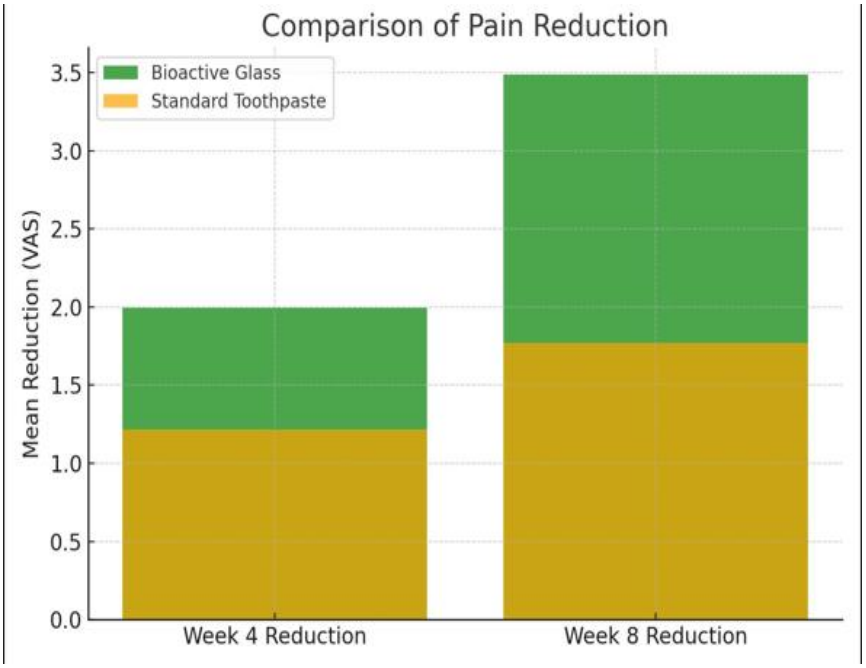

Figure 2Compasrison of Pain Reduction

Discussion

The findings of the present investigation indicated that the novel bioactive glass toothpaste produced a meaningful reduction in dentin hypersensitivity among orthodontic patients when compared with conventional care(11). The degree and rate of symptom improvement suggested that the formulation's capacity to occlude exposed dentinal tubules and promote mineral deposition remained effective even in the challenging environment created by fixed orthodontic appliances(12). This outcome aligned with previously documented mechanisms of bioactive glass technology, which consistently demonstrated rapid formation of a hydroxycarbonate apatite layer capable of reducing fluid movement within dentinal tubules. However, the magnitude of improvement observed in this cohort appeared slightly greater than what had been reported in general dental populations, suggesting that orthodontic patients, who often experience heightened enamel wear and increased plaque retention, might particularly benefit from enhanced remineralizing agents(13).

The comparison between the intervention and control groups highlighted a clinically relevant difference that extended beyond transient symptom relief. The sustained reduction in sensitivity throughout the evaluation period implied that the bioactive glass formulation provided not only immediate tubule occlusion but also continued surface stabilization as orthodontic forces persisted(14). Such durability has been acknowledged in earlier laboratory-based analyses, yet in vivo confirmation has remained limited. The current findings contributed to filling this gap by demonstrating consistent symptom control despite ongoing mechanical irritation and repeated exposure to acidic challenges, conditions typical during orthodontic therapy. The results therefore offered additional support for the concept that bioactive glass may outperform desensitizing agents relying solely on neural modulation, as the latter typically exhibit shorter-lived effects under comparable conditions(15).

The clinical implications of these results were noteworthy(16). Improved management of dentin hypersensitivity could enhance overall orthodontic tolerance, reduce treatment-related discomfort, and potentially improve adherence to oral-hygiene regimens(17). Patients experiencing sensitivity often avoid thorough brushing around brackets, leading to greater plaque accumulation and increased risk of decalcification. By mitigating this barrier, the bioactive glass toothpaste might indirectly support better periodontal outcomes and reduce the incidence of white spot lesions. Furthermore, enhanced comfort may encourage more consistent dietary choices and reduce reliance on acidic or softened foods that worsen enamel demineralization.

Several strengths strengthened the credibility of the findings. The study used a standardized desensitization assessment protocol, ensuring consistent and reproducible measurements across participants. The controlled comparison allowed an accurate evaluation of the toothpaste's effect against routine orthodontic care, reducing the likelihood that improvements were attributable to natural desensitization alone. The intervention period was sufficiently long to assess both the early and sustained responses to treatment, providing a more complete understanding of its clinical performance. Additionally, participant adherence was monitored closely, limiting confounding from inconsistent product use.

Nonetheless, important limitations required consideration. The sample size, while adequate to detect group differences, limited the ability to explore variations across subgroups such as age, baseline sensitivity severity, or bracket type. A larger cohort might have revealed more nuanced patterns or clarified whether certain patient characteristics influenced responsiveness to treatment. The reliance on patient-reported sensitivity scores, though clinically relevant, introduced an inherent subjective element. Objective measures, such as quantification of mineral deposition or tubule occlusion through imaging techniques, might have strengthened the biological interpretation of the results. Furthermore, the follow-up period, although sufficient for short-term assessment, did not determine whether the benefits persisted after orthodontic treatment completion or whether long-term maintenance would require continued use of the toothpaste.

While the study design minimized major sources of bias, it did not entirely account for environmental and behavioral factors that could influence sensitivity, such as dietary habits, brushing technique, or variations in orthodontic force levels. Future research could better control these variables or incorporate them into multivariate analyses to determine their interactions with desensitizing therapy. Moreover, direct comparison with other modern remineralizing agents, including nano-hydroxyapatite or arginine-based formulations, would help clarify whether bioactive glass offered a distinct clinical advantage or simply represented an alternative with comparable efficacy.

Further investigation would also benefit from integrating advanced diagnostic tools capable of capturing microstructural changes over time. High-resolution microscopy or quantitative light-induced fluorescence could verify the extent and stability of mineral layer formation, linking patient-reported outcomes with measurable biological effects. Longitudinal studies following patients beyond the active orthodontic phase would provide essential insight into whether the intervention prevented enamel wear or reduced long-term hypersensitivity recurrence. Additionally, exploring optimized delivery methods, such as gel formulations or professional in-office applications, might reveal whether greater concentrations or different application protocols yield superior or faster results.

Overall, the study contributed meaningful evidence supporting the use of bioactive glass toothpaste as an effective adjunct for managing dentin hypersensitivity during orthodontic treatment. The results suggested that its underlying mechanism remained robust under orthodontic conditions and that it offered clinically relevant improvements in patient comfort. Although the findings were encouraging, further work with expanded methodologies, larger samples, and extended observation periods would strengthen the understanding of its long-term value and refine its role within comprehensive orthodontic care.

Conclusion

The findings demonstrated that the bioactive glass toothpaste produced a more pronounced reduction in dentin hypersensitivity among orthodontic patients than the standard desensitizing formulation, indicating its potential value in routine clinical care. The consistent decrease in pain scores over the study period suggested meaningful benefits for individuals experiencing heightened sensitivity during orthodontic treatment. Overall, the evidence supported the practical applicability of this novel formulation, highlighting its relevance as an effective adjunct in managing discomfort associated with exposed dentin.

AUTHOR CONTRIBUTIONS

Author	Contribution
Fatima Tu Zohra*	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Aiman Zahra	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.
Abdul Wahab Ali	Significantly contributed to data collection and analysis. Reviewed and approved the final manuscript for publication.

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