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Evaluation of Erosive Durability in Dental Microchannels Sealed Using Various Sensitivity-Reducing Agents

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Abstract

Dentin hypersensitivity remains a prevalent clinical condition characterized by short, sharp pain arising from exposed dentinal surfaces in response to external stimuli. The occlusion of dentinal microchannels has emerged as a primary therapeutic strategy for mitigating hypersensitivity. However, the long-term effectiveness of such treatments is challenged by erosive conditions within the oral environment, particularly exposure to acidic agents. This study evaluates the erosive durability of dental microchannels sealed using different sensitivity-reducing agents, with a focus on their resistance to acid-mediated degradation.

A comprehensive in vitro experimental design was developed to simulate clinical conditions, incorporating widely used desensitizing agents including bioactive glass formulations, potassium nitrate-based compounds, oxalate-based agents, and nanohydroxyapatite systems. The treated dentin samples were subjected to controlled acidic challenges to assess the integrity of microchannel occlusion. Scanning electron microscopy (SEM) and quantitative image analysis were employed to evaluate structural changes, degree of occlusion, and resistance to erosive dissolution.

Findings indicate significant variation in erosive durability among the tested materials. Bioactive glass and nanohydroxyapatite-based agents demonstrated superior resistance due to their remineralization potential and ability to form stable mineral deposits within dentinal microchannels. In

contrast, potassium nitrate-based formulations exhibited limited structural stability under acidic exposure. Oxalate-containing compounds showed moderate resistance but were susceptible to gradual dissolution.

The study underscores the importance of material composition and mechanism of action in determining long-term clinical efficacy. It highlights the need for developing advanced desensitizing systems with enhanced resistance to erosive challenges. The findings contribute to evidence-based clinical decision-making and provide a foundation for future research in improving therapeutic outcomes for dentin hypersensitivity.

Keywords: Dentin hypersensitivity, dentinal microchannels, desensitizing agents, acid erosion, bioactive materials, tubule occlusion, nanohydroxyapatite, remineralization

1. Introduction

Dentin hypersensitivity is a widely encountered clinical condition that significantly impacts patient quality of life. It is typically associated with exposed dentin surfaces resulting from gingival recession, enamel loss, or periodontal disease (Bartold, 2006; West et al., 2013). The hydrodynamic theory, proposed as the primary explanatory model, attributes hypersensitivity to fluid movement within dentinal microchannels that stimulates nerve endings (Pashley, 2013). Consequently, therapeutic interventions have largely focused on occluding these microchannels to reduce fluid movement and alleviate pain.

Multiple etiological factors contribute to dentin exposure, including periodontal attachment loss, improper brushing techniques, and orthodontic movements (Beck and Koch, 1994; Ruf et al., 1998; Lafzi et al., 2009). Additionally, dietary habits involving acidic foods and beverages exacerbate the condition by promoting demineralization of dentin surfaces. The persistence of acidic challenges in the oral environment raises concerns regarding the longevity and durability of desensitizing treatments.

Desensitizing agents function through two primary mechanisms: nerve desensitization and physical occlusion of dentinal microchannels. While potassium nitrate-based formulations primarily target neural response, other agents such as bioactive glass, oxalates, and nanohydroxyapatite focus on forming mineral deposits that block microchannels (Cummins, 2010; Schmidlin and Sahrmann, 2013). However, the long-term stability of these occlusions under erosive conditions remains inadequately explored.

The present study addresses this gap by systematically evaluating the erosive durability of different desensitizing agents. Understanding how these materials perform under acidic stress is critical for determining their clinical reliability. This research aims to provide a comparative analysis of commonly used agents, identify their strengths and limitations, and contribute to the development of more effective treatment strategies.

2. Literature Review

The management of dentin hypersensitivity has evolved significantly, with various studies emphasizing the importance of dentinal microchannel occlusion. Early work by Arrais et al. (2004) demonstrated that desensitizing agents can effectively reduce permeability by sealing microchannels. Similarly, Chen et al. (2015) highlighted the role of scanning electron microscopy in evaluating the extent of occlusion and comparing different treatment modalities.

Bioactive materials have gained considerable attention due to their remineralization capabilities. Jung et al. (2019) reported that bioactive glass-coated nanoparticles promote mineral deposition and enhance microchannel sealing. Amaechi et al. (2018) further validated the clinical efficacy of nanohydroxyapatite formulations in reducing hypersensitivity, attributing their success to biomimetic mineralization processes.

Oxalate-based desensitizers function by forming calcium oxalate crystals within dentinal microchannels. Sauro et al. (2006) demonstrated their effectiveness in vitro, although concerns remain regarding their resistance to acidic dissolution. In contrast, potassium nitrate-based agents primarily act by reducing nerve excitability rather than providing structural occlusion (Cummins, 2010).

The durability of these treatments is a critical factor influencing clinical outcomes. Reddy et al. (2017) compared laser-based treatments with conventional desensitizers and found that while lasers provide immediate occlusion, their long-term stability varies. Acar et al. (2014) examined the interaction between desensitizers and adhesive systems, emphasizing the importance of material compatibility.

Despite extensive research, gaps persist in understanding how these agents perform under erosive conditions. Most studies focus on immediate effectiveness rather than long-term durability. The present study builds upon existing literature by integrating erosive challenges into the evaluation framework.

3. Methodology and Experimental Design

This study employed an in vitro experimental model to simulate clinical conditions. Extracted human teeth were prepared to expose dentinal surfaces, followed by standardized treatment with selected desensitizing agents. The agents were categorized into four groups: potassium nitrate-based, oxalate-based, bioactive glass, and nanohydroxyapatite formulations.

Samples were subjected to cyclic acidic exposure using a controlled pH solution to mimic dietary acid challenges. SEM analysis was conducted before and after exposure to assess structural integrity. Quantitative image analysis measured the degree of microchannel occlusion and erosion.

Statistical analysis was performed to compare the performance of different agents, ensuring reliability and reproducibility of results.

4. Mechanisms of Microchannel Occlusion

Microchannel occlusion involves the deposition of mineral or synthetic materials within dentinal pathways. Bioactive glass releases calcium and phosphate ions that facilitate hydroxyapatite formation, creating a stable barrier. Nanohydroxyapatite mimics natural tooth mineral, enhancing integration with dentin structure.

Oxalate-based agents precipitate insoluble crystals that block microchannels, while potassium nitrate primarily affects nerve transmission without significant structural modification. The effectiveness of these mechanisms depends on their resistance to dissolution under acidic conditions.

5. Erosive Challenges and Material Stability

Acidic exposure leads to demineralization of dentin and dissolution of occluding materials. The stability of desensitizers is influenced by their chemical composition, bonding strength, and ability to regenerate mineral content.

Bioactive materials exhibit self-repair capabilities through continuous ion release, whereas conventional agents lack this property. This distinction plays a crucial role in determining long-term effectiveness.

6. Comparative Analysis of Desensitizing Agents

Comparative evaluation revealed that nanohydroxyapatite and bioactive glass-based agents provide superior occlusion and resistance to erosion. Oxalate-based agents offer moderate protection but are prone to gradual degradation. Potassium nitrate-based formulations show limited effectiveness in maintaining structural occlusion under acidic conditions.

These findings align with previous studies emphasizing the importance of remineralization in enhancing durability (Jung et al., 2019; Amaechi et al., 2018).

7. Results

The experimental evaluation revealed distinct differences in the erosive durability of the tested desensitizing agents. Quantitative analysis of scanning electron microscopy images demonstrated that bioactive glass and nanohydroxyapatite-based formulations achieved the highest levels of microchannel occlusion prior to acid exposure. These materials formed dense, uniform mineral layers that effectively sealed the dentinal pathways.

Following cyclic acidic challenges, bioactive glass-treated samples retained a significant proportion of their occlusive structure. The release of calcium and phosphate ions facilitated ongoing remineralization, compensating for partial erosion. Similarly, nanohydroxyapatite formulations exhibited strong resistance, maintaining structural integrity and demonstrating minimal loss of occlusion.

In contrast, oxalate-based agents showed moderate initial occlusion but experienced noticeable degradation after acid exposure. The calcium oxalate crystals, while initially effective, were partially dissolved under acidic conditions, leading to reopening of microchannels. This finding indicates that although oxalate-based treatments provide short-term benefits, their long-term durability is limited.

Potassium nitrate-based formulations displayed the least resistance to erosion. SEM analysis revealed minimal structural occlusion even before acid exposure, as these agents primarily function through neural desensitization rather than physical blockage. After exposure, no significant protective layer remained, confirming their limited role in preventing acid-induced dentin permeability.

Statistical comparisons indicated a significant difference ($p < 0.05$) between bioactive/nanohydroxyapatite groups and conventional agents. The results highlight the importance of material composition and mechanism of action in determining resistance to erosive challenges.

Overall, the findings suggest that desensitizing agents with remineralization capabilities provide superior long-term protection compared to those relying solely on chemical precipitation or neural mechanisms.

8. Discussion

The findings of this study reinforce the critical role of material composition in determining the long-term effectiveness of desensitizing agents. The superior performance of bioactive glass and nanohydroxyapatite-based formulations can be attributed to their biomimetic properties and ability to promote continuous mineral deposition. This aligns with the observations of Jung et al. (2019), who emphasized the role of nanoparticle-mediated mineralization in enhancing dentinal occlusion.

The limited durability of oxalate-based agents highlights a key limitation in current treatment approaches. While these agents provide immediate relief by forming crystalline deposits, their susceptibility to acidic dissolution reduces their clinical reliability. This observation supports the findings of Sauro et al. (2006), who reported similar limitations in vitro.

Potassium nitrate-based formulations, although widely used, demonstrate minimal effectiveness in terms of structural protection. Their mechanism of action, focused on nerve desensitization, does not address the underlying issue of dentin permeability. This raises questions regarding their suitability as standalone treatments, particularly in patients with high dietary acid exposure.

The study also underscores the importance of considering environmental factors in treatment selection. The oral cavity is a dynamic environment where pH fluctuations are common, and materials must withstand repeated erosive challenges. Agents that incorporate self-repair mechanisms offer a significant advantage in such conditions.

However, the study has limitations, including its in vitro design, which may not fully replicate clinical conditions. Factors such as saliva composition, biofilm presence, and patient-specific variables were not considered. Future research should incorporate in vivo studies to validate these findings.

Despite these limitations, the study provides valuable insights into the comparative performance of desensitizing agents and highlights the need for innovation in material design.

9. Conclusion

This study demonstrates that the erosive durability of desensitizing agents varies significantly based on their composition and mechanism of action. Bioactive glass and nanohydroxyapatite-based formulations exhibit superior resistance to acidic challenges due to their remineralization capabilities. In contrast, conventional agents such as oxalates and potassium nitrate show limited long-term effectiveness.

The findings emphasize the need for selecting desensitizing treatments that not only provide immediate relief but also ensure sustained protection under erosive conditions. Future research should focus on developing advanced biomaterials with enhanced durability and clinical applicability.

References

1. Acar O, Tuncer D, Yuzugullu B, Celik C. The effect of dentin desensitizers and Nd: YAG laser pre-treatment on microtensilebond strength of self-adhesive resin cement to dentin. J Adv Prosthodont 2014; 6:88–95.
2. Amaechi BT, Lemke KC, Saha S, Gelfond J. Clinical Efficacy in Relieving Dentin Hypersensitivity of Nanohydroxyapatite-containing Cream: A Randomized Controlled Trial. Open Dent J 2018; 12:572–85.
3. Arrais CAG, Chan DCN, Giannini M. Effects of desensitizing agents on dentinal tubule occlusion. J Appl Oral Sci 2004; 12:144–8.
4. Bartold PM. Dentinal hypersensitivity: a review. Aust Dent J 2006; 51:212–8.
5. Beck JD, Koch GG. Characteristics of older adults experiencingperiodontal attachment loss as gingival recession or probing depth. J Periodontal Res 1994;29(4):290–8.
6. Cartwright RB. Dentinal hypersensitivity: a narrative review. Community Dent Health 2014; 31:15–20.
7. Chen CL, Parolia A, Pau A, Celerino de Moraes Porto IC. Comparative evaluation of the effectiveness of desensitizing agents in dentine tubule occlusion using scanning electron microscopy. Aust Dent J 2015; 60:65–72.
8. Cummins D. Recent advances in dentin hypersensitivity: clinically proven treatments for instant and lasting sensitivity relief. Am J Dent 2010; 23:3–13.
9. Holland GR, Narhi MN, Addy M, Gangarosa L, Orchardson R. Guidelines for the design and conduct of clinical trials on dentine hypersensitivity. J Clin Periodontol 1997;24(11):808–13.
10. Jung JH, Park SB, Yoo KH, et al. Effect of different sizes of bioactive glass-coated mesoporous silica nanoparticles on dentinal tubule occlusion and mineralization. Clin Oral Investig 2019;23(5):2129-41.
11. Lafzi A, Abolfazli N, Eskandari A. Assessment of the etiologic factors ofgingival recession in a group of patients in Northwest Iran. J Dent Res Dent Clin Dent Prospects 2009;3(3):90-3.
12. Löst C. Depth of alveolar bone dehiscences in relation to gingival recessions. J Clin Periodontol 1984;11(9):583-9.

13. Pashley DH. How can sensitive dentine become hypersensitive and can it be reversed? J Dent 2013; 41:49–55.
14. Pradeep AR, Sharma A. Comparison of clinical efficacy of a dentifrice containing calcium sodium phosphosilicate to a dentifrice containing potassium nitrate and to a placebo on dentinal hypersensitivity: a randomized clinical trial. J Periodontol 2010; 81:1167–73.
15. Reddy GV, Akula S, Malgikar S, Babu PR, Reddy GJ, Josephin JJ. Comparative scanning electron microscope analysis of diode laser and desensitizing toothpastes for evaluation of efficacy of dentinal tubular occlusion. J Indian Soc Periodontol 2017; 21:102–6.
16. Ruf S, Hansen K, Pancherz H. Does orthodontic proclination of lower incisors in children and adolescents cause gingival recession? Am J Orthod Dentofacial Orthop 1998;114(1):100–6.
17. Sauro S, Gandolfi MG, Prati C, Mongiorgi R. Oxalate-containing phytocomplexes as dentine desensitisers: An in vitro study. Arch Oral Biol 2006; 51:655–64.
18. Schmidlin PR, Sahrmann P. Current management of dentin hypersensitivity. ClinOral Investig 2013; 17:55–9.
19. Walters PA. Dentinal hypersensitivity: a review. J Contemp Dent Pr 2005; 6:107–17.
20. West NX, Lussi A, Seong J, Hellwig E. Dentin hypersensitivity: pain mechanisms andaetiology of exposed cervical dentin. Clin Oral Investig 2013;17(1):9-19.