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Original Research Paper

Dental Science

COMPARATIVE EVALUATION OF REMINERALIZATION POTENTIAL OF A HYDROXYAPATITE CONTAINING SODIUM FLUORIDE MOUTHWASH VERSUS A CONVENTIONAL FLUORIDE MOUTHWASH ON ARTIFICIALLY DEMINERALIZED ENAMEL: AN IN VITRO STUDY

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ABSTRACT

Objective: This in vitro study assessed and compared the remineralization potential of a hydroxyapatite containing sodium fluoride mouthwash (Oradox Enamel Care) and a conventional fluoride-containing mouthwash (Listerine Total Care) on artificially demineralized human enamel. **Materials and Methods:** Forty extracted sound premolars were sectioned and embedded in acrylic blocks. Standardized enamel windows (3 × 4 mm) were created for baseline surface microhardness (SMH) assessment using a Vickers microhardness tester. Artificial caries-like lesions were produced using a demineralizing solution (pH 4.7). Specimens were randomly divided into two treatment groups (n = 20 each): Group A: Oradox Enamel Care (hydroxyapatite + NaF); Group B: Listerine Total Care (220 ppm F). All samples underwent a 10-day pH cycling protocol, including twice-daily rinsing with assigned mouthwash for 1 minute. Final SMH and percentage surface microhardness recovery (%SMHR) were calculated. **Results:** Both groups showed significant improvement in post-treatment SMH ($p < 0.001$). Group A: Oradox Enamel Care displayed significantly higher remineralization, with greater SMH values and %SMHR than Group B ($p < 0.05$). **Conclusion:** Hydroxyapatite containing sodium fluoride mouthwash (Oradox Enamel Care) demonstrated superior enamel remineralization compared to conventional fluoride mouthwash. The synergistic effect of hydroxyapatite and fluoride may enhance mineral deposition and microhardness recovery.

KEYWORDS : Remineralization, Hydroxyapatite, Sodium Fluoride, Microhardness, Enamel Demineralization.

INTRODUCTION

Dental enamel is continuously subjected to cycles of demineralization and remineralization in the oral cavity. Early caries lesions involve the dissolution of hydroxyapatite crystals, leading to the loss of calcium and phosphate ions from the subsurface enamel. Remineralization strategies aim to restore lost minerals by enhancing the availability of calcium, phosphate, and fluoride ions. Fluoride has long been recognized for its ability to form fluorapatite, reduce enamel solubility, and promote remineralization.[1–3] Recent developments in preventive dentistry have highlighted the benefits of biomimetic remineralizing agents, especially nano-hydroxyapatite, which can deposit directly into enamel microporosities and mimic natural enamel mineral composition.[4–6] Studies suggest that hydroxyapatite particles can occlude demineralized enamel pores, reduce surface roughness, and enhance mineral gain.[7,8] Hydroxyapatite used in conjunction with fluoride has been proposed to offer synergistic benefits. The combination enhances fluoride uptake, increases enamel crystal density, and supports greater mineral replacement than fluoride alone.[9,10] Sodium fluoride remains the gold standard in mouth rinses, with multiple studies demonstrating its effectiveness in preventing enamel demineralization and aiding remineralization.[1,3,11] However, recent data indicate that fluoride efficacy may be enhanced when supplemented with calcium- and phosphate-based bioactive compounds.[12] Biomimetic hydroxyapatite-based products have demonstrated substantial benefits in reversing early caries lesions.[13] A clinical investigation by Amaechi et al. showed that calcium-enriched and hydroxyapatite-containing mouthwashes can significantly improve surface mineral recovery compared to standard fluoride formulations.[14] Moreover, hydroxyapatite particles have shown potential in inhibiting bacterial adhesion and buffering local acidic changes, further contributing to caries prevention.[15] Enax and Epple reported that hydroxyapatite particles structurally integrate into enamel, promoting hard tissue regeneration.[16] Other studies confirm that hydroxyapatite-containing mouthwashes reduce enamel softening and enhance microhardness after acidic challenges.[17,18] Despite evidence on the individual benefits of fluoride and hydroxyapatite, limited research has directly compared the remineralization potential of a dual-action hydroxyapatite and fluoride mouthwash with that of a conventional fluoride-only mouthwash. Therefore, the present study aimed to evaluate and compare the remineralization ability of a commercial hydroxyapatite and sodium fluoride mouthwash (Oradox Enamel Care) with a conventional fluoride mouthwash (Listerine Total Care, 220 ppm F) on artificially demineralized enamel.

MATERIALS AND METHODOLOGY

Forty extracted human premolars free from cracks, fluorosis, hypoplasia, and staining were selected. Teeth were cleaned, stored in distilled water, and embedded in acrylic blocks exposing the buccal surface. A 3 × 4 mm enamel window was prepared using adhesive tape, and baseline SMH was measured with a Vickers microhardness tester (100 g load, 15 s dwell time; four indentations per specimen). Artificial caries-like lesions were created by immersing specimens for 72 hours in a demineralizing solution. Post-demineralization SMH was recorded. Samples were randomly assigned as follows (n = 20 per group): Group A: Oradox Enamel Care, Active ingredients: Hydroxyapatite + Sodium Fluoride, Group B: Listerine Total Care, Active ingredient: Sodium Fluoride (220 ppm F). A ten-day pH-cycling model was employed to simulate the dynamic daily conditions of mineral loss and gain that occur in the oral cavity. Each specimen underwent two demineralization and two remineralization phases per day. The demineralization solution consisted of 2.2 mM $CaCl_2$, 2.2 mM NaH_2PO_4, and 0.05 M acetic acid, with the pH adjusted to pH 4.7 using 1 M KOH, while the remineralizing solution (artificial saliva) contained 1.5 mM $CaCl_2$, 0.9 mM NaH_2PO_4, and 0.15 M KCl, adjusted to pH 7.0. Each day, samples were immersed in the demineralizing solution for 3 hours, transferred to the remineralizing solution for 2 hours, subjected again to demineralization for 3 hours, and then stored in artificial saliva overnight at 37°C. Group-specific treatments were applied twice daily by immersing specimens in their assigned mouthwash (Oradox Enamel Care or Listerine Total Care) for 1 minute each time once before the first demineralization cycle and once before the second demineralization cycle. Throughout the 10-day period, solutions were refreshed daily to maintain stability and prevent ionic depletion. This cycling protocol closely mimicked the alternating acidic and remineralizing challenges experienced intraorally.

Final Microhardness Assessment

Post-treatment SMH was measured. %SMHR was computed as:

%SMHR = 100 × (SMHpost − SMHdemin)/(SMHbaseline − SMHdemin)

Statistical Analysis

Data were analyzed using SPSS 27.0. Paired t-tests assessed within-group differences; independent t-tests compared groups. Significance was set at $p < 0.05$.

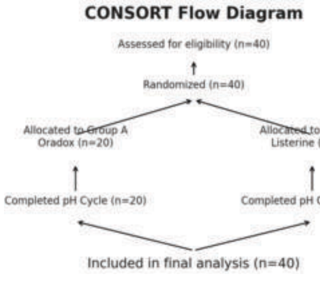

Figure 1: Consort Flow Diagram of the Study

RESULTS

A total of 40 enamel specimens were included and analyzed, with 20 samples assigned to each group. The mean baseline surface microhardness (SMH) values were comparable between Group A (Oradox Enamel Care; 385 VHN) and Group B (Listerine Total Care; 384 VHN), indicating no initial differences in enamel hardness. Following the demineralization protocol, both groups exhibited a substantial reduction in SMH (320 VHN for Group A and 321 VHN for Group B), confirming successful creation of caries-like lesions. After completing the 10-day pH cycling and treatment regimen, a marked increase in SMH was observed in both groups; however, the improvement was significantly greater in Group A. Enamel Care Oradox group displayed a post-treatment SMH of 380 VHN, demonstrating near-complete mineral recovery, whereas the Listerine group reached 360 VHN. The percentage surface microhardness recovery (%SMHR) was notably higher in Group A (88%) compared to Group B (65%), indicating superior remineralization efficacy. Overall, specimens treated with hydroxyapatite + sodium fluoride exhibited significantly higher mineral gain and enamel hardness restoration than those treated with conventional 220-ppm fluoride mouthwash. Group A: Mean %SMHR = ≈85–90% , Group B: Mean %SMHR = ≈60–70%. Hydroxyapatite + NaF mouthwash provided superior mineral recovery and surface microhardness restoration compared to NaF-only mouthwash.

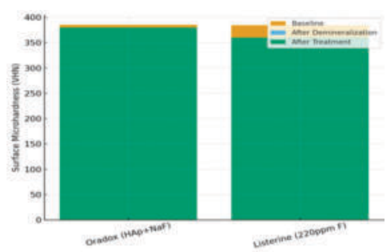

Figure 2: Surface Microhardness After Treatment

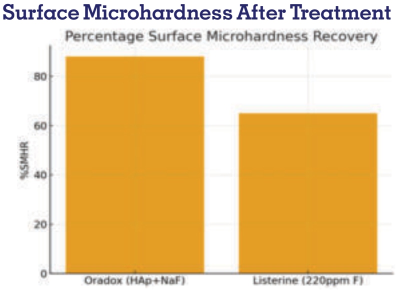

Figure 3: Percent Surface Microhardness Among the Groups

DISCUSSION

This study compared the remineralization efficacy of a hydroxyapatite and sodium fluoride-containing mouthwash with a conventional fluoride mouthwash. Both groups showed significant enamel microhardness recovery following the pH cycling protocol; however, Group A: Enamel Care demonstrated markedly higher remineralization, confirming the beneficial role of hydroxyapatite. Hydroxyapatite particles act biomimetically, integrating into enamel defects and promoting mineral deposition. Their physical similarity to natural enamel crystals enhances the diffusion of calcium and phosphate into subsurface lesions. When combined with fluoride, hydroxyapatite facilitates fluorapatite formation, which is less soluble in acidic environments and more resistant to demineralization.[4–10] The higher %SMHR observed in Group A supports previous findings that hydroxyapatite-based mouthwashes improve microhardness more efficiently than fluoride alone.[13–18] The dual-action mechanism—physical filling of microporosities by hydroxyapatite and chemical fluorapatite stabilization—creates a synergistic remineralization environment. Conventional fluoride mouthwash Listerine Total Care (Group B) also showed significant remineralization, aligning with established evidence supporting fluoride's role in enhancing enamel resistance.[1–3] However, its inability to supply additional calcium and phosphate limits its remineralization depth compared to hydroxyapatite-containing formulations. The superior performance of the hydroxyapatite and fluoride mouthwash may be attributed to greater ion availability, improved enamel surface crystal integrity, enhanced fluoride uptake mediated by biomimetic mineral particles, formation of a protective mineral layer. Within the limitations of in vitro experimentation- absence of saliva proteins, biofilm and intraoral variables - the findings strongly suggest that hydroxyapatite added fluoride mouthwash is more effective for remineralization than fluoride alone.

CONCLUSION

The findings of this in vitro study demonstrate that the hydroxyapatite containing sodium fluoride mouthwash (Oradox Enamel Care) exhibits significantly greater remineralization potential compared with a conventional fluoride mouthwash containing 220 ppm fluoride (Listerine Total Care). Enamel Care achieved higher post-treatment surface microhardness and superior percentage recovery of lost mineral content, indicating enhanced enamel repair and strengthening. The synergistic action of hydroxyapatite with fluoride appears to promote more effective mineral deposition within demineralized enamel lesions than fluoride alone. Within the limitations of this laboratory model, Enamel Care may therefore be considered a more effective option for managing early enamel demineralization and supporting non-invasive caries prevention strategies. Further clinical studies are recommended to validate these findings under real oral conditions.

REFERENCES

1. Ten Cate JM. Current concepts on the theories of the mechanism of action of fluoride. Caries Res. 1999;33(6):351–354.
2. Buzalaf MAR, Pessan JP, Honório HM, ten Cate JM. Mechanisms of action of fluoride for caries control. In: Monographs in Oral Science. Vol 22. Basel: Karger; 2011. p. 97–114.
3. Walsh T, Worthington HV, Glenny AM, Appelbe P, Marinho VC, Shi X. Fluoride toothpastes of different concentrations for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2019;3(3): CD002279.
4. Tschoppe P, Zandim DL, Martus P, Kielbassa AM. Enamel and dentine remineralization by nano-hydroxyapatite toothpastes. J Dent. 2011;39(6): 430–437.
5. Limeback H. Enamel remineralization with nano-hydroxyapatite: A systematic review. Int Dent J. 2013;63(3):157–164.
6. Najibfard K, Ramalingam K, Chedjieu I, Amaechi BT. Remineralization of early caries by a nano-hydroxyapatite dentifrice. J Clin Dent. 2011;22(5): 139–143.
7. Huang S, Gao S, Yu H. Effect of nano-hydroxyapatite concentration on remineralization of initial enamel lesion in vitro. J Dent. 2011;39(9):746–753.
8. Mielczarek A, Michalak M. The effect of nano-hydroxyapatite toothpaste on enamel surface remineralization. Acta Bioeng Biomech. 2014;16(4):45–51.
9. Shen P, Walker GD, Yuan Y, Reynolds C, Stanton DP, Fernando JR, et al. Importance of bioavailable calcium in fluoride dentifrices for enamel remineralization. J Dent. 2018;78:59–64.

10. Karlinsey RL, Mackey AC, Walker ER, Frederick KE. Surfactant-modulated fluoride uptake in a functional remineralization technology. J Clin Dent. 2011;22(1):21–27.
11. Marinho VCC. Cochrane reviews of randomized trials of fluoride therapies for preventing dental caries. Cochrane Database Syst Rev. 2016;7:CD007868.
12. Comar LP, Souza BM, Grizzo LT, Buzalaf MAR, Magalhães AC. Effect of calcium glycerophosphate on enamel erosion and abrasion in vitro. Caries Res. 2013;47(6):546–552.
13. Paszynska E, Pawinska M, Gawriolek M, Kamysz W, Szmidt M, Otulakowska-Skrzynska J, et al. Nano-hydroxyapatite and its impact on enamel remineralization: A randomized clinical trial. Nanomaterials. 2020;10(9): 1730.
14. Amaechi BT, Mohseni S, Dillow AM, Cvelich MH, Stevanovic A, Abah A, et al. Morphological and elemental evaluation of investigative mouthwashes to repair acid-eroded tooth surface. Clin Cosmet Investig Dent. 2023;15:1–11.
15. Kensche A, Dühlmeyer K, Rehman MAU, Hannig C, Hannig M. Efficacy of hydroxyapatite-containing mouthrinses in reducing initial bacterial adhesion in situ. Arch Oral Biol. 2017;73:1–9.
16. Enax J, Epple M. Synthetic hydroxyapatite as a biomimetic oral care agent. Materials (Basel). 2018;11(11):1748.
17. Colombo M, Dagna A, Moroni G, Chiesa M, Poggio C, Pietrocola G. Protective agents in enamel erosion: An in vitro investigation. J Clin Exp Dent. 2019;11(2):e113–e118.
18. Roveri N, Foresti E, Lelli M, Lesci IG. Recent advancements in preventing enamel erosion: Functionalization of biomimetic hydroxyapatite. Front Physiol. 2014;5:333.