Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 14 July 2026
Revised 15 Aug 2026
Accepted 02 Sep 2026

Natural Resources for Human Health 2026, Vol. 6 (20s): 1125–1135

KEYWORDS:
Dental bleaching; enamel remineralisation; NovaMin; BioMin; bioactive glass; calcium; phosphorus; SEM-EDS.

Comparison of Two Bioactive Glass Incorporated Toothpastes for Restoring Mineral Loss After Dental Bleaching with 35% Hydrogen Peroxide and 35% Carbamide Peroxide: An in Vitro Study

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ABSTRACT: Dental bleaching may cause alterations in the mineral composition of enamel. This in vitro study aimed to evaluate and compare the effects of NovaMin and BioMin-containing toothpastes on the calcium and phosphorus content of enamel following bleaching with 35% hydrogen peroxide and 35% carbamide peroxide.

Materials and Methods: Forty-eight extracted human maxillary anterior teeth were allocated to two groups according to the bleaching agent used: 35% hydrogen peroxide and 35% carbamide peroxide. Each group was further divided into three subgroups (n = 8): bleaching alone, bleaching followed by NovaMin toothpaste, and bleaching followed by BioMin toothpaste. Enamel mineral deposition was assessed by scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS). Calcium and phosphorus contents were analysed using analysis of variance followed by the Tukey's honestly significant difference (HSD) test. Statistical significance was set at $p < 0.05$.

Results: Bleaching alone resulted in lower calcium and phosphorus contents compared with the remineralisation groups. Following 35% hydrogen peroxide bleaching, the mean calcium content was 14.51% in the control group, compared with 31.46% and 32.53% following NovaMin and BioMin application, respectively. Corresponding phosphorus values were 7.08%, 15.74%, and 15.51%. Following 35% carbamide peroxide bleaching, mean calcium content was 14.93% in the control group, compared with 29.57% and 29.64% following NovaMin and BioMin application, respectively, while phosphorus content was 7.41%, 15.09%, and 15.85%. Both remineralisation groups showed significantly greater calcium and phosphorus contents than the respective control groups ($p < 0.001$). However, no significant differences were found between NovaMin and BioMin for either mineral.

Conclusions: Within the limitations inherent to in-vitro studies, it can be concluded that application of remineralising agents produces a significant increase in enamel calcium and phosphate content following bleaching with 35% hydrogen peroxide and 35% carbamide peroxide. No statistically significant difference was detected between NovaMin and BioMin in this remineralising effect; however, given the limited power of these specific comparisons, this finding should not be interpreted as evidence that the two bioactive glass–containing toothpastes perform equivalently. Further studies with larger, adequately

powered sample sizes, or a formally designed equivalence trial, are needed to draw definitive conclusions regarding their comparative efficacy.

1. INTRODUCTION

Tooth colour is an important component of dental aesthetics, and the increasing emphasis on white smiles has led to a growing demand for tooth whitening procedures.[1] Tooth discoloration may be intrinsic or extrinsic, resulting from factors such as developmental disturbances, medications, excessive fluoride exposure, smoking, and consumption of chromogenic foods and beverages.[2]

Dental bleaching is a conservative and effective method for improving tooth colour. Hydrogen peroxide (HP) and carbamide peroxide (CP) are the most commonly used bleaching agents. Carbamide peroxide decomposes to release hydrogen peroxide, which diffuses through enamel and dentin and generates reactive oxygen species that break down pigmented chromophores responsible for tooth discoloration.[3'4'5] However, bleaching may also cause alterations in enamel morphology and mineral composition, including loss of calcium and phosphorus and increased mineral solubility.[6-10] Remineralising agents have therefore been investigated to counteract mineral alterations following bleaching. Fluoride and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) have traditionally been used for enamel remineralization.[11] More recently, bioactive glasses have gained attention because of their ability to release calcium and phosphate ions and promote the formation of an appetite-like layer on dental hard tissues.[12]

NovaMin is a calcium sodium phosphosilicate bioactive glass that releases calcium and phosphate ions in an aqueous environment, promoting formation of a hydroxyapatite-like layer on the tooth surface.[13] BioMin F® is a fluoride-containing bioactive glass that releases calcium, phosphate, and fluoride ions and may promote formation of fluoridated apatite, thereby enhancing enamel remineralization.[14,15]

Although both materials have demonstrated remineralising potential, limited evidence is available regarding the comparative evidence of remineralising potential of NovaMin and BioMin F® after bleaching with hydrogen peroxide and carbamide peroxide .

Therefore, this in vitro study aimed to compare the ability of two bioactive glass-containing toothpastes, NovaMin and BioMin F®, to restore mineral alterations in enamel following bleaching with 35% hydrogen peroxide and 35% carbamide peroxide using scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS).

2. MATERIALS AND METHODS

2.1 Source of Data

Human teeth (maxillary incisors and canines) extracted for different therapeutic reasons were used for the study. The teeth were examined carefully, discarding those with cracks, caries or structural enamel defects. The final study sample consisted of 48 teeth which were cleaned and stored in thymol for 5 days.

2.2 Inclusion criteria:

Teeth indicated for extraction due to poor periodontal Health

Maxillary anterior teeth with intact coronal structure

Teeth without attrition and abrasion

2.3 Exclusion criteria:

Teeth with cracks

Teeth with caries

Teeth with structural enamel defects

Teeth with severe erosion

2.4 Materials and equipment's used in the study:

Contra-angle hand piece

Carborundum discs

EDTA

Artificial saliva

Deionized water

Bleaching agents 35% hydrogen peroxide and 35% carbamide peroxide

Remineralising agents Biomin F containing fluoro-calcium-phosphosilicate bioactive glass as the active remineralising component, along with glycerine, polyethylene glycol 400, sodium laural sulfate, Tio_2, and 530 ppm of fluoride.

Novamin containing toothpaste (vantaj) containing 5% w/w calcium sodium phosphosilicate along with silicin dioxide, calcium oxide, sodium oxide, phosphorus pentoxide and sodium fluoride 1450 ppm.

Scanning electron microscope with energy dispersive spectroscopy

2.5 Methodology

Sample Preparation:

A total of 48 extracted human anterior teeth (n = 8 per group across 6 groups) were included in this study. This sample size is consistent with comparable studies evaluating remineralisation of enamel after application of remineralising agents[16]. The Teeth Were Sectioned from The Cemento-Enamel Junction Using Water Refrigerated Diamond Disc. The Roots Were Discarded. The Crowns Were Divided into 2 Groups (Group 1 & Group 2), each group into 3 subgroups and Crowns Were Embedded into Acrylic Resin Leaving a Window to Explore Enamel. The Samples Were Stored in commercially available Saliva substitute (salivary spray; torion lifesciences,india) at 4 degree centigrade until initiation of the procedure. All Samples Were Washed with Deionised Water for 30 Seconds Before Bleaching Treatment.

Application of the Bleaching and Remineralising Agents: The samples belonging to groups 1a,1b,1c underwent three 15 minute treatments with 35% hydrogen peroxide (pola office) to a thickness of about 1 mm between applications the material was removed with an aspirator, followed by washing for 30 seconds with deionised water. Then in groups 1b and 1c novamin paste and biomin paste was applied to a thickness of about 1mm for 5 minutes, followed by removal with deionised water. Then groups 2a,2b,2c underwent 30 minute treatments with 35% carbamide peroxide gel to a thickness of about 1mm and then removed by aspiration, followed by washing with deionised water for 30 seconds. In groups 2a and 2b novamin paste and biomin paste was applied for 5 minutes to a thickness of about 1mm followed by removal with deionised water. Following each application, the specimens were immersed in saliva substitute and stored at 4 degrees centigrade until next treatment cycle. This procedure was performed twice daily for a period of 2 weeks [17].

Table 1 summarises treatment protocol used in each group

1a	35% hydrogen peroxide
1b	35% hydrogen peroxide followed by application of novamin
1c	35% hydrogen peroxide followed by application of biomin
2a	35% carbamide peroxide
2b	35% carbamide peroxide followed by application of novamin
2c	35% carbamide peroxide followed by application of biomin

Natural Resources for Human Health
eISSN: 2583-1194

Scanning electron microscope with EDS analysis

The samples were first dried and then gold sputtered in mini sputter coating machine. Then proportions of calcium and phosphorus were determined on a semi quantitative basis with a microanalytical system –EDX.the operating parameters used were: acceleration voltage 20 kv Resolution of 127.1 Ev. For microanalysis, we located the central zone of the sample and performed three measurements: one of the central zone and another two at two points equidistant to the first, along the diagonal of each sample. The proportions of calcium and phosphorus in the enamel were recorded and the mean value of the weight percentage of calcium and phosphorus was calculated and results were tabulated.

3. RESULTS AND DISCUSSION

The Present Study Was Carried Out to Compare Two Bioactive Glass Incorporated Toothpastes for Restoring Mineral Loss After Dental Bleaching With Hydrogen Peroxide 35% And Carbamide Peroxide 35% by using SEM with EDS

Statistical Methods: The recorded data were compiled in Microsoft Excel and analyzed using SPSS software (version 20.0; SPSS Inc., Chicago, IL, USA). Data normality was assessed using the Kolmogorov–Smirnov test. A two-way analysis of variance (ANOVA) was performed with bleaching agent (35% hydrogen peroxide vs. 35% carbamide peroxide) and remineralising agent (control, NovaMin, BioMin) as fixed factors, including their interaction term, to evaluate the main and interaction effects on enamel calcium and phosphorus content. Post hoc pairwise comparisons were performed using Tukey's honestly significant difference (HSD) test to control the family-wise error rate across multiple comparisons. Effect sizes (Cohen's d) and 95% confidence intervals were calculated for all pairwise comparisons. A p-value < 0.05 was considered statistically significant.

Group Wise Distribution of Samples:

Group	Description	No. of Samples
1a	35% hydrogen peroxide	8
1b	35% hydrogen peroxide followed by application of novamin	8
1c	35% hydrogen peroxide followed by application of biomin	8
2a	35% carbamide peroxide	8
2b	35% carbamide peroxide followed by application of novamin	8
2c	35% carbamide peroxide followed by application of biomin	8

Evaluation of Enamel Remineralisation by SEM with EDS:

Remineralisation after bleaching was not done in control samples of both groups, so the degree of remineralisation could not be evaluated in control groups. The mean proportion of calcium and phosphorus in both groups are given in tables 1-4 & Graphs 1-4.

Table 1: Proportion of Phosphorus in the enamel in various subgroups of Group 1 (Hydrogen Peroxide Group)

Group	N	Mean	SD	95% CI	Comparison	P-value
Group 1a	8	7.08	0.337	6.79-7.36	1a vs 1b	<0.001*
Group 1b	8	15.74	0.916	14.97-16.50	1b vs 1c	0.678
Group 1c	8	15.51	1.287	14.43-16.58	1c vs 1a	<0.001*

*Statistically Significant Difference (P-value<0.05); CI: Confidence Interval

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eISSN: 2583-1194

Graph 1

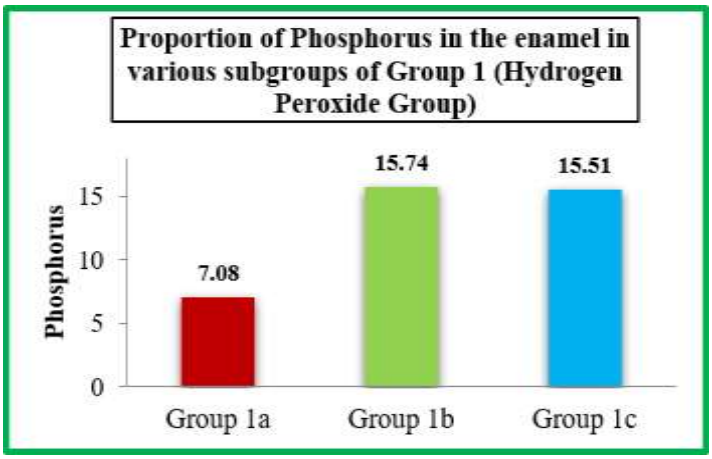


Table 1 represents the mean amount of phosphorus in Group 1. As evident from the Table, there is a significant difference between subgroups 1a, 1b & 1a,1c but insignificant difference between subgroups 1b&1c. same is illustrated in Graph 1

Table 2: Proportion of Calcium in the enamel in various subgroups of Group 1 (Hydrogen Peroxide group)

Group	N	Mean	SD	95% CI	Comparison	P-value
Group 1a	8	14.51	0.781	13.84-15.14	1a vs 1b	<0.001*
Group 1b	8	31.46	2.015	29.78-33.14	1b vs 1c	0.326
Group 1c	8	32.53	2.215	30.69-34.38	1c vs 1a	<0.001*

*Statistically Significant Difference (P-value<0.05); CI: Confidence Interval

Graph 2

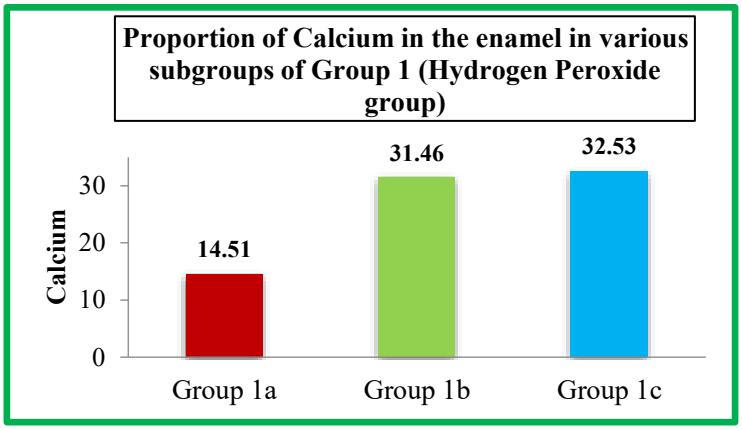


Table 2 represents the mean amount of calcium in Group1. As evident from the table, there is a significant difference between subgroups 1a, 1b & 1a,1c but insignificant difference between subgroups 1b&1c. same is illustrated in Graph 2

Table 3: Proportion of Phosphorus in the enamel in various subgroups of Group 2 (carbamide peroxide group)

Group	N	Mean	SD	95% CI	Comparison	P-value

Group 2a	8	7.41	0.501	6.98-7.82	2a vs 2b	<0.001*
Group 2b	8	15.09	0.771	14.45-15.73	2b vs 2c	0.141
Group 2c	8	15.85	1.148	14.89-16.81	2c vs 2a	<0.001*

*Statistically Significant Difference (P-value<0.05); CI: Confidence Interval

Graph 3

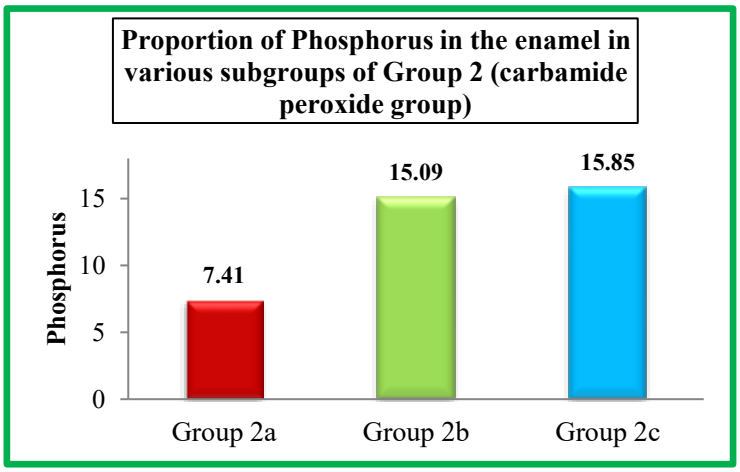


Table 3 represents the mean amount of phosphorus in Group 3. As evident from the table, there is a significant difference between subgroups 2a, 2b & 2a,2c but insignificant difference between subgroups 2b&2c. same is illustrated in Graph 3.

Table 4: Proportion of Calcium in the enamel in various subgroups of Group 2 (carbamide peroxide group)

Group	N	Mean	SD	95% CI	Comparison	P-value
Group 2a	8	14.93	0.483	14.53-15.34	2a vs 2b	<0.001*
Group 2b	8	29.57	0.521	29.14-30.02	2b vs 2c	0.905
Group 2c	8	29.64	1.353	28.51-30.76	2c vs 2a	<0.001*

*Statistically Significant Difference

(P-value<0.05); CI: Confidence Interval

Graph 4

Natural Resources for Human Health
eISSN: 2583-1194

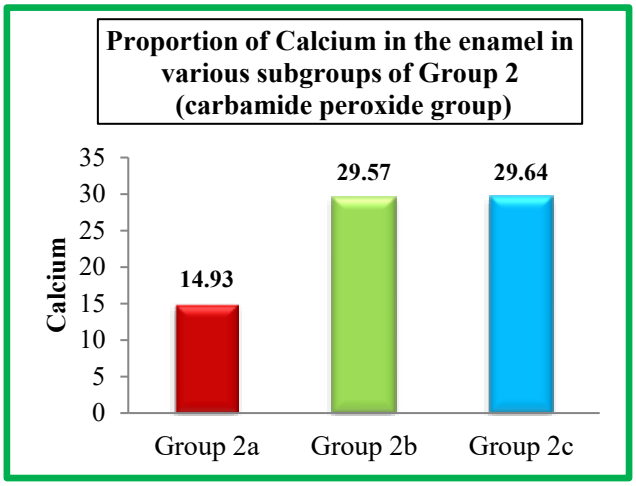


Table 4 represents the mean amount of calcium in Group2. As evident from the table, there is a significant difference between subgroups 2a, 2b & 2a,2c but insignificant difference between subgroups 2b&2c. same is illustrated in Graph 4

3.4 Discussion

Dental bleaching is commonly used to improve the colour of teeth affected by intrinsic and extrinsic stains. Although it is an effective aesthetic procedure, bleaching may cause mineral loss and changes in the enamel surface, including a reduction in micro hardness and elastic modulus. Mild tooth sensitivity has also been reported after bleaching.[18-20]. Although both agents release hydrogen peroxide, 35% H_2O_2 provides a direct and rapid peroxide source, whereas 35% carbamide peroxide gradually releases H_2O_2 (~12.6% theoretical equivalent). Thus, they are not chemically equivalent. Their inclusion allowed evaluation of remineralisation following bleaching systems with different peroxide-release profiles. The subsequent remineralising treatment and saliva-like storage simulated the clinical sequence of bleaching-induced mineral alteration followed by post-bleaching mineral recovery.

Therefore, the use of remineralising agents following bleaching may help to reduce these changes and restore the mineral content of enamel[21].Several remineralising agents have been used after dental bleaching. Fluoride was one of the earlier materials used for this purpose and has been shown to reduce mineral loss by promoting the formation of fluorapatite[22]. Casein phosphopeptide-amorphous calcium phosphate with fluoride (CPP-ACPF) has also been used to restore mineral loss after bleaching[22]. More recently, bioactive glasses have gained attention because they interact with dental hard tissues and promote the formation of a hydroxyapatite layer on the tooth surface.[15,24]

NovaMin is a bioactive glass that has been used for enamel remineralisation. In the presence of water, it releases calcium and phosphate ions and increases the local pH, which favours the formation of a calcium phosphate layer. This layer subsequently develops into a hydroxyapatite-like layer on the enamel surface.[25]

BioMin F is another bioactive glass containing calcium, phosphate and fluoride. It releases these ions gradually and promotes the formation of Fluor apatite on the tooth surface. Previous studies have reported its remineralising potential on demineralised enamel.[26] However, studies comparing BioMin and NovaMin after dental bleaching, particularly using SEM-EDS, are limited. Therefore, the present study compared the remineralising potential of NovaMin and BioMin following bleaching with hydrogen peroxide and carbamide peroxide.

Human anterior teeth extracted for periodontal reasons were used in the present study. The teeth were selected from the 40–50-year age group to reduce variation in the initial mineral composition of enamel. The crown portions were sectioned and prepared for analysis. The initial mineral composition of the enamel was not assessed before treatment, which is a limitation of the study, But the levels of phosphate and calcium were analysed after application of bleaching agents and then after applying remineralising agents.

The specimens were bleached with 35% hydrogen peroxide and 35% carbamide peroxide. Hydrogen peroxide was applied for 15 minutes according to the protocol described by de Arruda et al.[27] while carbamide peroxide was applied for 30 minutes.

Following bleaching, the specimens were treated with NovaMin and BioMin toothpastes and evaluated using SEM-EDS. Calcium and phosphorus levels were recorded to assess changes in the mineral composition of enamel. Fluoride peaks were not detected in the EDS analysis, which may be related to the low photon energy of fluoride.

SEM-EDS is useful for evaluating the elemental composition of enamel. Calcium and phosphorus levels can provide an indication of changes associated with demineralisation and remineralisation. In the present study, both NovaMin and BioMin groups showed higher calcium and phosphorus values than their respective control groups.

In Group 1, the mean phosphorus content was 15.74% in the NovaMin group, 15.51% in the BioMin group and 7.08% in the control group. The difference between the NovaMin and BioMin groups was not statistically significant. The mean calcium content was 31.46% in the NovaMin group, 32.53% in the BioMin group and 14.51% in the control group. Although the BioMin group showed a slightly higher calcium value, the difference between the two remineralising agents was not statistically significant.

A similar pattern was observed in Group 2. The mean phosphorus content was 15.09% in the NovaMin group, 15.85% in the BioMin group and 7.42% in the control group. The mean calcium content was 29.57% in the NovaMin group, 29.64% in the BioMin group and 14.93% in the control group. No statistically significant difference was observed between the NovaMin and BioMin groups.

The calcium and phosphorus content in the control groups was lower than the reported normal enamel values of 33.9 ± 6.9% and 16.7 ± 2.3%, respectively. This reduction suggests mineral loss following bleaching and is in agreement with the findings of Llena et al.[21]

In the present study, the null hypothesis was rejected as the use of remineralising agents resulted in an increase in the calcium and phosphate content of bleached enamel. These findings are in agreement with previous studies by Ismail B et al, Fallahzadeh et al which reported the beneficial effects of remineralising agents following bleaching.[28]

Compared with NovaMin, fewer studies have evaluated the enamel remineralising potential of BioMin. Most available studies on BioMin have focused on dentinal tubule occlusion and the management of dentinal hypersensitivity. In the present study, BioMin increased the calcium and phosphorus content of enamel after bleaching. This finding is similar to previous research in which the remineralising effect of BioMin was evaluated using EDS.[15]

Only limited studies have directly compared NovaMin and BioMin for enamel remineralisation. Most comparative studies have focused on dentinal tubule occlusion, where BioMin has shown better occluding ability. This may be related to its smaller particle size, which could allow better penetration into dentinal tubules.

In the present study, no statistically significant difference was found between NovaMin and BioMin in restoring calcium and phosphate content lost during bleaching, consistent with the findings of Imran Farooq et al. [29], who similarly reported no significant difference in remineralization capacity between the two agents. However, group sizes in the present study were not determined by a priori power calculation for these head-to-head comparisons; effect sizes ranged from negligible to moderate (Cohen's d = 0.07–0.78), with a correspondingly limited achieved power of 5–31%. This finding should therefore be interpreted as an absence of detected difference rather than evidence that the two agents perform equivalently, and a study specifically powered to detect small-to-moderate differences, or a formally designed equivalence trial with a pre-specified margin, would be required to support a true equivalence claim.

4. CONCLUSION

Within the limitations inherent to in-vitro studies, it can be concluded that application of remineralising agents produces a significant increase in enamel calcium and phosphate content following bleaching with 35% hydrogen peroxide and 35% carbamide peroxide. No statistically significant difference was detected between NovaMin and BioMin in this remineralising effect; however, given the limited power of these specific comparisons (5–31%), this finding should not be interpreted as evidence that the two bioactive glass–containing toothpastes perform equivalently. Further studies with larger, adequately powered sample sizes, or a formally designed equivalence trial, are needed to draw definitive conclusions regarding their comparative efficacy.

Natural Resources for Human Health
eISSN: 2583-1194

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support and guidance provided by the Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Srinagar, Jammu and Kashmir, India. The authors also acknowledge the assistance provided by the Research Laboratory, National Institute of Technology (NIT) Srinagar, in facilitating the laboratory investigations. The authors express their sincere gratitude to all individuals who contributed to the successful completion of this study.

AUTHOR CONTRIBUTIONS

Farooq ahmad wani : Conceptualization, Investigation, methodology, laboratory analysis.

Lakshita singh : Data Curation, Formal Analysis.

Adipiscing D. Elit: Supervision, Writing—Review & Editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval for this in vitro study was obtained from the ethics committee of govt. dental college and hospital, Srinagar, j&k India. The study was reviewed and recommended by the committee.

DATA AVAILABILITY STATEMENT

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

[1] Christensen GJ. Are snow-white teeth really so desirable? J Am Dent Assoc. 2005 Jul;136(7):933-5.
[2] Hattab FN. Tooth Discoloration: Causes and Clinical Presentation—Part I. J Oral Health Comm Dent 2024;18(2):63–74.
[3] Llena C, Martinez-Galdón O, Forner L , Gimeno-Mallench L ,Rodríguez-Lozano FJ, Gambini J. Hydrogen Peroxide Diffusion through Enamel and Dentin. Materials (Basel).2018 sep 12;11(9): 1694.
[4] Kashima-Tanaka M, Tsujimoto Y, Kawamoto K, Senda N, Ito K, Yamazaki M. Generation of free radicals and/or active oxygen by light or laser irradiation of hydrogen peroxide or sodium hypochlorite. J Endod. 2003 Feb;29(2):141-3
[5] Dahl JE, Pallesen U. Tooth bleaching--a critical review of the biological aspects. Crit Rev Oral Biol Med. 2003;14(4):292-304.
[6] Rotstein I, Dankner E, Goldman A, Heling I, Stabholz A, Zalkind M. Histochemical analysis of dental hard tissues following bleaching. J Endod. 1996 Jan;22(1):23-5. doi: 10.1016/S0099-2399(96)80231-7. PMID: 8618081.
[7] Farawati FAL, Hsu SM, O'Neill E, Neal D, Clark A, Esquivel-Upshaw J. Effect of carbamide peroxide bleaching on enamel characteristics and susceptibility to further discoloration. J Prosthet Dent. 2019 Feb;121(2):340-346. doi: 10.1016/j.prosdent.2018.03.006. Epub 2018 Aug 20. PMID: 30139674; PMCID: PMC6363879.
[8] Titley K, Torneck CD, Smith D. The effect of concentrated hydrogen peroxide solutions on the surface morphology of human tooth enamel. J Endod. 1988 Feb;14(2):69-74. doi: 10.1016/S0099-2399(88)80004-9. PMID: 3162942.
[9] Potocnik I, Kosec L, Gaspersic D. Effect of 10% carbamide peroxide bleaching gel on enamel microhardness, microstructure, and mineral content. J Endod. 2000 Apr;26(4):203-6. doi: 10.1097/00004770-200004000-00001. PMID: 11199718.
[10] Lee KH, Kim HI, Kim KH, Kwon YH. Mineral loss from bovine enamel by a 30% hydrogen peroxide solution. J Oral Rehabil. 2006 Mar;33(3):229-33. doi: 10.1111/j.1365-2842.2004.01360. x. PMID: 16512890.
[11] Kwon YH et al.: Change of enamel after Er:YAG and CO2 laser irradiation and fluoride treatment. Photomed Laser Surg 23(4): 389-394, 2005
[12] Taha AA, Patel MP, Hill RG, Fleming PS. The effect of bioactive glasses on enamel remineralization: A systematic review. J Dent. 2017 Dec; 67:9-17. doi: 10.1016/j.jdent.2017.09.007. Epub 2017 Sep 20. PMID: 28939485.

[13] Vahid Golpayegani M, Sohrabi A, Biria M, Ansari G. Remineralisation Effect of Topical NovaMin Versus Sodium Fluoride (1.1%) on Caries-Like Lesions in Permanent Teeth. J Dent (Tehran). 2012 Winter;9(1):68-75. Epub 2012 Mar 31. PMID: 22924104; PMCID: PMC3422065.

[14] Montaser MM, Youssef H, Mahmoud GM. Comparison of the remineralisation effectiveness of three remineralising agents on artificial enamel lesions: an in vitro study. BDJ Open. 2025 May 5;11(1):44. doi: 10.1038/s41405-025-00330-y. PMID: 40324997; PMCID: PMC12053640.

[15] Bakry AS, Abbassy MA, Alharkan HF, Basuhail S, Al-Ghamdi K, Hill R. A Novel Fluoride Containing Bioactive Glass Paste is Capable of Re-Mineralizing Early Caries Lesions. Materials (Basel). 2018 Sep 6;11(9):1636. doi: 10.3390/ma11091636. PMID: 30200640; PMCID: PMC6163288.

[16] Soneta SP, Hugar SM, Hallikerimath S, Gokhale N, Joshi RS, Uppin C. A Comparative Evaluation of Remineralising Potential of Commonly Used Fluoridated Toothpaste, Herbal Toothpaste, Toothpaste with Zinc Hydroxyapatite, and Toothpaste with Calcium Sucrose Phosphate in Children: A Scanning Electronic Microscopic Study. Int J Clin Pediatr Dent. 2022;15(Suppl 2): S158-S163. doi: 10.5005/jp-journals-10005-2143. PMID: 35645532; PMCID: PMC9108835.

[17] Eldeeb AI, Tamish NO, Madian AM. Effect of Biomin F toothpaste and Diode laser on remineralization of white spot lesions (in vitro study). BMC Oral Health. 2024 Jul 30;24(1):866. doi: 10.1186/s12903-024-04589-9. PMID: 39080606; PMCID: PMC11290108.

[18] Coceska, E., Gjorgievska, E., Coleman, N.J., Gabric, D., Slipper, I.J., Stevanovic, M. And Nicholson, J.W. (2016), Enamel Alteration Following Tooth Bleaching And Remineralization. Journal Of Microscopy, 262: 232-244. Https://Doi.Org/10.1111/Jmi.12357

[19] Fatima N, Ali Abidi SY, Meo AA. In Vitro Comparative Study of Two Different Bleaching Agents on Micro-hardness Dental Enamel. J Coll Physicians Surg Pak. 2016 Feb;26(2):83-6. PMID: 26876390.

[20] Mounika A, Mandava J, Roopesh B, Karri G. Clinical evaluation of color change and tooth sensitivity with in-office and home bleaching treatments. Indian J Dent Res. 2018 Jul-Aug;29(4):423-427. doi: 10.4103/ijdr.IJDR_688_16. PMID: 30127190.

[21] Poggio C, Grasso N, Ceci M, Beltrami R, Colombo M, Chiesa M. Ultrastructural evaluation of enamel surface morphology after tooth bleaching followed by the application of protective pastes. Scanning. 2016 May;38(3):221-6. doi: 10.1002/sca.21263. Epub 2015 Sep 16. PMID: 26376339.

[22] Ferizoli B, Cresswell-Boyes AJ, Anderson P, Lynch RJM, Hill RG. Effects of fluoride on in vitro hydroxyapatite demineralisation analysed by 19F MAS-NMR. Front Dent Med. 2023 May 24; 4:1171827. doi: 10.3389/fdmed.2023.1171827. PMID: 39916921; PMCID: PMC11797780.

[23] Llena C, Esteve I, Rodríguez-Lozano FJ, Forner L. The application of casein phosphopeptide and amorphous calcium phosphate with fluoride (CPP-ACPF) for restoring mineral loss after dental bleaching with hydrogen or carbamide peroxide: An in vitro study. Ann Anat. 2019 Sep; 225:48-53. doi: 10.1016/j.aanat.2019.05.005. Epub 2019 Jul 2. PMID: 31271888.

[24] Hsu, S.-M., Alsafadi, M., Vasconez, C., Fares, C., Craciun, V., O'Neill, E., Ren, F., Clark, A., & Esquivel-Upshaw, J. (2021). Qualitative Analysis of Remineralization Capabilities of Bioactive Glass (NovaMin) and Fluoride on Hydroxyapatite (HA) Discs: An in Vitro Study. Materials, 14(14), 3813. https://doi.org/10.3390/ma14143813

[25] Mohanty P, Padmanabhan S, Chitharanjan AB. An in Vitro Evaluation of Remineralization Potential of Novamin(®) on Artificial Enamel Sub-Surface Lesions Around Orthodontic Brackets Using Energy Dispersive X-Ray Analysis (EDX). J Clin Diagn Res. 2014 Nov;8(11): ZC88-91. doi: 10.7860/JCDR/2014/9340.5177. Epub 2014 Nov 20. PMID: 25584326; PMCID: PMC4290336.

[26] Jain, A. A., VK, R., Gheware, A., Mhatre, A., Wadhwani, N., Chaudhari, R. (2024). Comparative assessment of enamel surface remineralisation with three different dentifrices: An energy dispersion x-ray spectroscopy analysis. Journal of Contemporary Orthodontics, 8(4), 461-468. https://doi.org/10.18231/j.jco.2024.070

[27] de Arruda AM, dos Santos PH, Sundfeld RH, Berger SB, Briso AL. Effect of hydrogen peroxide at 35% on the morphology of enamel and interference in the de-remineralization process: an in situ study. Oper Dent. 2012 Sep-Oct;37(5):518-25. doi: 10.2341/11-112-L. Epub 2012 Mar 21. PMID: 22433029.

[28] Ismail B, Soliman Z, El-Askary F. Evaluation of the effects of different remineralizing agents on the microhardness and mineral content of bleached enamel along different storage times. BMC Oral Health. 2026 Feb 17;26(1):416. doi: 10.1186/s12903-026-07749-1. PMID: 41699587; PMCID: PMC12954970.

[29] Farooq I, Ali S, Farooqi FA, AlHumaid J, Binhasan M, Shabib S, Vohra F, Abduljabbar T. Enamel Remineralization Competence of a Novel Fluoride-Incorporated Bioactive Glass Toothpaste-A Surface Micro-Hardness, Profilometric, and Micro-Computed Tomographic Analysis. Tomography. 2021 Nov 9;7(4):752-766. doi: 10.3390/tomography7040063. PMID: 34842827; PMCID: PMC8628907.