Assessment of Color Change of Artificial White Spot Lesions after Sandblasting with Bioactive Glass, Resin Infiltration, or Microabrasion Followed by Color Stability Test by pH Cycling: An in Vitro Study

Abdulla MW AL-Shamma, Manhal A Majeed, Hussein M Wajih

Department of Restorative and Aesthetic Dentistry, College of Dentistry, University of Baghdad, Baghdad, Iraq

Abstract

Introduction: This study aimed to assess the color change of human teeth with artificial enamel white spot lesions (WSLs) after sandblasting with bioactive glass, resin infiltration, and microabrasion and to test color stability after pH cycling. Methods: Fifty extracted human mandibular first molars were randomly assigned into five groups: Sound, WSLs (untreated), and WSLs sandblasted with bioactive glass (Sylc), WSLs treated by resin infiltration (ICON), and WSLs treated by microabrasion (Opalustre), respectively. All specimens underwent a pH cycling procedure. The color parameters for each specimen were assessed using an Easyshade dental spectrophotometer at different time stages then the color changes (ΔE) were calculated. Results: The demineralization step recorded a significant color change ($P < 0.01$). All treatments significantly reduced the lesion color change ($P < 0.01$), amongst which ICON recorded the greatest color reduction ($\Delta E = 2.94$). The pH cycling resulted in a negative color impact for the Sylc group. Conclusion: Resin infiltration was able to enhance the WSLs' color and reestablish the natural color of the teeth efficiently as compared to bioactive glass and microabrasion.

Keywords: White spot lesion, color change, resin infiltration, microabrasion, bioactive glass, pH cycling

Introduction

White spot lesions (WSLs) are often associated with heavy plaque accumulation, a high sugar or acidic diet, and inadequate oral care.[1] Dental plaque organic acids trigger a demineralization process that changes the refractive index (RI) of enamel, making the tooth clinically whitish.[2] The treatment of WSLs generally includes noninvasive methods, including remineralization, minimally invasive methods like resin infiltration, or invasive ways such as microabrasion and composite restorations.[3]

Theaim of this study is to evaluate the color changes of artificial WSLs when treated with either sandblasting with bioactive glass, resin infiltration, or microabrasion and to test the stability of the treatment after being subjected to pH cycling.

Materials and Methods

The study protocol was approved by the local ethical committee of the College of Dentistry, University of Baghdad (Project No. 495522). The design of the study is in vitro, single-blinded (the data analyst was blind to the intervention). The sample size was determined using G*power 3.1.9.7 (Heinrich-Heine-Universitaİt Duİsseldorf, Duİsseldorf, Germany). Given a power of 85%, a two-sided alpha error probability of 0.05, a medium effect size of 0.25 for F, and a total of five groups with four measurements each, the required sample size was determined to be ten per group. Materials used in this study (Supplementary Table 1) are

Access this article online

Quick Response Code:

Website: https://journals.lww.com/dhyp

DOI: 10.4103/denthyp.denthyp_77_24

Address for correspondence: Abdulla MW AL-Shamma (Abdulla Mohammed Wajeeh Al-Shamma), Department of Restorative and Aesthetic Dentistry, College of Dentistry, University of Baghdad, Baghdad, Al-Mansour, 615, 26, 2, Iraq.
E-mail: abdullah.mohammed1600@codental.uobaghdad.edu.iq

Received: 21 October 2024 Revised: xx Month xxxx
Accepted: 2 January 2025 Published: xx Month 2025

How to cite this article: AL-Shamma AMW, Majeed MA, Wajih HM. Assessment of Color Change of Artificial White Spot Lesions after Sandblasting with Bioactive Glass, Resin Infiltration, or Microabrasion Followed by Color Stability Test by pH Cycling: An in Vitro Study. Dent Hypotheses 2025;0:??.

available via https://doi.org/10.6084/m9.figshare.28028870.v1.

Fifty sound human permanent mandibular first molar teeth extracted for periodontal reasons were collected from different dental clinics in Baghdad city. A magnifying EyeMag Pro S loupes 4.5X (ZEISS, Oberkochen, Germany) was used to examine and exclude teeth showing cracks, stains, fluorosis, or developmental anomalies on their buccal surfaces. Teeth were thoroughly washed and cleaned, polished, and disinfected with a 0.1% thymol solution (Innu-Science Canada Inc., Sainte-Julie, Canada) for 48 h, followed by storage in distilled water at 4°C till use,[4] and then were immersed individually (except for sound group) into demineralizing solution (4.6 pH adjusted lactic acid [LobaChemie, Mumbai, India] [0.1 M]) and stored in an incubator at 37°C for of 1 week.[5] The samples were randomly assigned (www.random.org) into five groups ($n = 10$): Sound group not subjected to the demineralization stage, WSL group left without treatment, Sylc group treated with Sylc bioactive glass powder (Denfotex Research Ltd, London, UK), ICON group treated with ICON resin infiltration (DMG, Hamburg, Germany), and Opalustre group treated with Opalustre microabrasion slurry (Ultradent, South Jordan, UT, USA). Sylc powder was applied using the AquaCare air abrasion twin unit (Velopex, London, UK) with an air pressure range of 40–46 psi, using a circular movement for 10 s, then the powder was allowed to settle for 60 s before washing with tap water. Each tooth was then soaked for 1 week in simulated oral fluid (Supplementary Table 1) that was refreshed daily.[6] ICON treatment consisted of the application of 15% hydrochloric acid for 120 s to the lesion surface, followed by washing and application of 99% ethanol for 30 s. Finally, the infiltrant was massaged over the surface and left for 180 s before being light-cured for 40 s.[7] Opalustre slurry was applied in a circular motion for 30 s using Opalcups attached to a low-speed handpiece at a speed of 300 rpm.[8] The pH cycle started by soaking each tooth sample in the demineralizing solution (15 ml) (Supplementary Table 1) for 6 h, followed by soaking in the remineralizing solution (15 ml) (Supplementary Table 1) for 18 h. This cycle was repeated 10 times over a period of 14 days.[5]

Color analysis was carried out using an Easyshade advance 4.0 spectrophotometer (VITA Zahnfabrik, Bad Saĭckingen, Germany). The color measurements were taken at baseline, after demineralization, after treatment, and after pH cycling. The measurement was accomplished by positioning the device probe tip against the surface of the sample. The color parameters (L^*, a^*, b^*) represented with a CIE system were recorded on three consecutive readings and the average was calculated. The color change (ΔE) was calculated for each tooth sample after each stage (i.e., after demineralization [$\Delta E1$], after treatment [$\Delta E2$], and after pH cycling [$\Delta E3$]) compared to tooth baseline color parameters according to the equation: $\Delta E = ((\Delta L^*)^2 (\Delta a^*)^2 (\Delta b^*)^2)^{1/2}$ [2]

Data were analyzed via one-way analysis of variance, Tukey post hoc test, and paired t-test using SPSS 24 (IBM Corp, Armonk, USA).

Results

A considerable color change (i.e., the high value of $\Delta E1$) was detected after demineralization, and the difference between groups was not significant ($p = 0.978$). After treatment, there was a statistically significant reduction in color change ($\Delta E2$) for all treated groups ($p < 0.01$) [Figure 1]. ICON (resin infiltration) recorded the lowest value (2.94 ± 0.92), which was statistically significant compared to other treatment groups ($p < 0.01$) [Figure 1]. Only the Sylc group (sandblasting with bioactive glass) recorded a significant increase in ΔE after pH cycling ($p < 0.01$). The sound group recorded the lowest $\Delta E3$ value (1.86 ± 0.17), which was significantly lower compared to the treatment groups (p

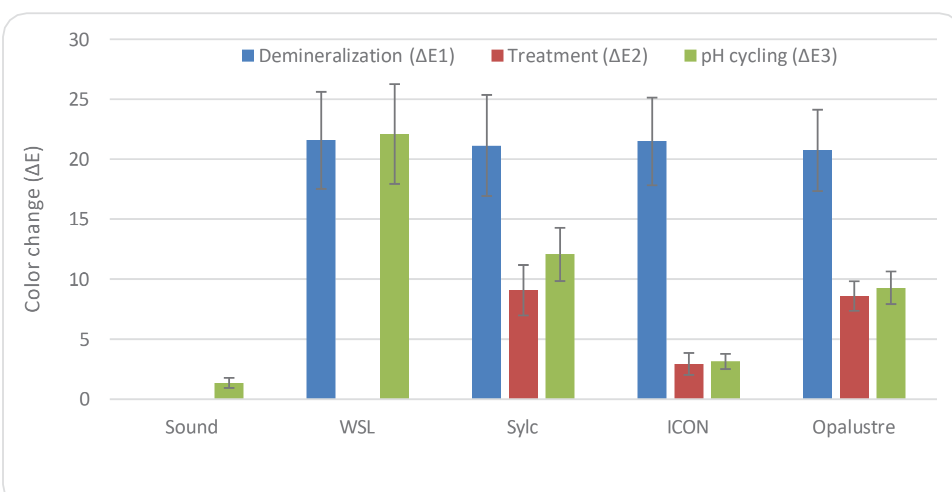

Figure 1: Bar chart showing the differences in color change values among different groups and stages (Sylc: Sandblasting with bioactive glass, ICON: Resin infiltration, and Opalustre Microabrasion).

< 0.001) except for the ICON group, which has comparable $\Delta E3$ ($p = 0.697$) [Figure 1].

Discussion

Sound enamel has an RI of 1.6; unlikely, the RI of water-filled microporosities is 1.33, and that of air-filled porosities is 1.0. Accordingly, when the light ray passes through different interfaces, it is deviated, reflected, and observed as chalky white.[9] The development of WSL in this study through using organic acid closely resembles natural WSL being shallow in depth with the highest mineral loss as compared to other methods.[5,10] It has been documented in the literature that color is regarded as stable only if ΔE was not higher than 3.7.[11] In the present study, demineralization resulted in a whitish enamel which is due to the variation in RIs between demineralized and sound enamel as described earlier. Another contributing factor is the increased roughness of the WSL surface, which might affect the normal reflection of light.[4,12]

Only ICON treatment fully restored the baseline color of the tooth ($\Delta E2$ value of 2.94). ICON is a low-viscosity resin, mainly triethylene glycol dimethacrylate. It has a penetration coefficient of 147 cm/s and a RI of 1.52.[13] When such resin infiltrates lesion microporosities, it fills the empty spaces between the hydroxyapatite crystals in a capillary pattern, giving enamel an RI of 1.46–1.52, which matches more closely to sound enamel (1.62).[14] This masking ability comes in agreement with many previous studies.[15,16] The superiority of ICON over other treatments could be related to its penetration depth into the lesion, which may reach up to 182.2 μm.[17]

The ability of Opalustre to reduce color change is believed to be induced by its combined erosive and abrasive actions, ending with the riddance of the highly porous outermost layer and the establishment of a new surface with a lower roughness.[4,18] In spite of color improvement, Opalustre failed to completely hide the unesthetic color of WSL ($\Delta E2 > 3.7$); this may be accused to the fact that microabrasion in this study was performed in a single application, which may be insufficient to remove the full lesion depth.[3]

Upon contact with an aqueous solution, Sylc calcium sodium phosphosilicate bioactive glass particles dissolve, leading to rising the pH level and promoting the precipitation of hydroxyapatites and the formation of hydroxycarbonate apatites layer on the enamel surface.[5] The glass particles attach physically and adhere chemically to the surface microporosities, creating a thick layer of calcium and phosphate.[19] However, this mineral deposition is confined to the outer surface, and it is expected to reduce demineralization progress but can impede mineral ions diffusion into the lesion body, thus confining enamel remineralization to the subsurface zone.[20] This might explain the inadequate color improvement achieved by this group ($\Delta E2 = 9.09$). According to the results of our study, the after-effect of the pH cycle was somewhat disconcerting, especially when it comes with Sylc treatment. This is believed to be the result of loss of minerals and changes in the porosity of the enamel surface. The newly formed carbonated hydroxyapatite crystals became more soluble than the surrounding sound enamel hydroxyapatite crystals. This can lead to microporosities formation.[21]

With respect to the limitations of in vitro studies, the results of the present study could not simulate the exact real-life situations. In addition, teeth variations in their degree of crystallization and enamel thickness are added limitations of the study.

Funding

This research study is self-funded.

Author contributions

All authors participated in conceiving and designing the study. AMW and MAM contributed to the selection of the demineralization procedure, treatment modalities, pH cycling, and supervision of the study. HMW collected and prepared the study samples, performed all the experiments, and collected the data. AMW and HMW performed the statistical data analysis and drafted the manuscript and abstract of the article. MAM provided logistic support and interpretation of results. All authors have critically reviewed and approved the final draft and are responsible for the content of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by the Department of Restorative and Aesthetic Dentistry, College of Dentistry, University of Baghdad, Baghdad, Iraq.

References

1. Mohammed Hussain AA, Rafeeq RA. Efficacy of three commercially available fluoride releasing varnishes in remineralization of artificial white spot lesions evaluated by laser fluorescence: an in vitro study. Dent Hypotheses 2022;13:117–20.
2. Kim Y, Son HH, Yi K, Kim H-Y., Ahn J, Chang J. The color change in artificial white spot lesions measured using a spectroradiometer. Clin Oral Investig 2012;17:139–46.
3. Hammad SM, El-Wassefy NA, Alsayed MA. Evaluation of color changes of white spot lesions treated with three different treatment approaches: an in-vitro study. Dent Press J Orthod 2020;25: 26–7.
4. Chabuk MM, Al-Shamma AM. Surface roughness and microhardness of enamel white spot lesions treated with different treatment methods. Heliyon 2023;9:1–11.
5. Zhang J, Lynch RJM, Watson TF, Banerjee A. Remineralisation of enamel white spot lesions pre-treated with chitosan in the presence of salivary pellicle. J Dent 2018;72:21–8.

6. Ahmed HS. Effect of different non-invasive and micro-invasive treatment modalities of white spot lesions on microhardness of human enamel. Egypt Dent J 2021;67:3767–75.
7. Abd El-Monem R, Abdelaziz A, Abd El-Geleel O. Comparing the color masking effect of ICON and PROSEAL on primary enamel white spot lesions—a randomized controlled clinical trial. Egypt Dent J 2022;68:99–111.
8. Paic M, Sener B, Schug J, Schmidlin PR. Effects of microabrasion on substance loss, surface roughness, and colorimetric changes on enamel in vitro. Quintessence Int 2008;39:517–22.
9. Kim S, Kim E, Jeong T, Kim JW. The evaluation of resin infiltration for masking labial enamel white spot lesions. Int J Paediatr Dent 2011;21:241–8.
10. Magalhães AC, Moron BM, Comar LP, Wiegand A, Buchalla W, Buzalaf MAR. Comparison of cross-sectional hardness and transverse microradiography ofartificial carious enamel lesions induced by different demineralising solutions and gels. Caries Res 2009;43:474–83.
11. Dogra S, Goyal V, Gupta AK, *et al.* Spectrophotometric evaluation of color change in tooth enamel defects using resin infiltrate: an in vivo study. Int J Clin Pediatr Dent 2020;13:150–4.
12. Hussein KM, Al-Shamma AM. Effect of staining and brushing on the surface roughness of white spot lesions treated with resin infiltration technique. Indian J Public Health Dev 2019;10:3423–8.
13. Saccucci M, Corridore D, di Carlo G, Bonucci E, Cicciu' M, Vozza I. Assessment of enamel color stability of resins infiltration treatment in human teeth: a systematic review. Int J Environ Res Public Health 2022;19:1–19.
14. Rocha Gomes Torres C, Borges AB, Torres LMS, Gomes IS, de Oliveira R. Effect of caries infiltration technique and fluoride therapy on the colour masking of white spot lesions. J Dent 2011; 39:202–7.
15. Abdelhafez MN, Mustafa D, Nour KA. Color stability of artificial white spot lesions treated with resin infiltration. Egypt Dent J 2020;66:2729–38.
16. Paris S, Meyer-Lueckel H. Masking of labial enamel white spot lesions by resin infiltration—a clinical report. Quintessence Int 2009;40: 713–8.
17. Turska-Szybka A, Andrzejczuk M, Lewandowska MS, Gozdowski D, Olczak-Kowalczyk D. Resin infiltration of natural caries lesions on smooth surfaces of primary teeth—in vitro studies. Dent Med Probl 2014;51:308–17.
18. El Sayed HM, Abo elezz A, Fahmy OMI. Effect of three treatment modalities for white spot enamel lesions on enamel surface roughness and micro-hardness. Dent Sci Update 2022;3:127–37.
19. Rahee SS, Jehad RH. Comparing the effectiveness of using three different re-mineralizing pastes on remineralisation of artificially induced white spot lesion. J Bagh Coll Dent. 2023;35:35–45.
20. Al-Janabi SZ, Al-Dahan ZAA. The effects of nano-hydroxyapatite and casein phosphopeptide-amorphous calcium phosphate in preventing loss of minerals from teeth after exposure to an acidic beverage: an in vitro study. J Bagh Coll Dent 2015;27:132–7.
21. Liu G, Yang L, Gao L, *et al.* Durability of infiltrated resin application on white spot lesions after different challenges: an ex vivo study. J Prosthet Dent 2024;131:500–7.