Original Article

IN VITRO, INFLUENCE OF IN-OFFICE DENTAL WHITENING ON THE COLOR OF TEETH TREATED WITH RESIN INFILTRATION

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ABSTRACT

This investigation aims to evaluate the outcome of In-Office bleaching on the color of teeth treated with ICON resin infiltration. From extracted human premolar teeth, enamel-dentin specimens were prepared and randomly arranged into four groups of 10 teeth each (N = 40). In-office bleaching was performed after completing the discoloration process for Group 1 (Control) and Group 4. The same bleaching process was applied after resin infiltration treatment for groups 2 and 3. Then resin infiltration procedures were implemented. A single group (Group 4) showed a significant difference with a baseline mean of (5.252) and a mean of (5.885) after demineralization, a mean of (4.458) after resin infiltration process, a mean of (2.551) after staining procedure and final bleaching mean of (4.691), indicating the presence of bleaching effect on the resin infiltrated teeth surfaces. Depending on the degree of tooth pigmentation, resin infiltration may act as a semipermeable barrier for carbamide peroxide gels. A positive bleaching response was observed for low vs. high tooth pigmentation.

Key words: Whitening, Resin Infiltration, Bleaching, Color.

Introduction

Incipient caries lesion presented in a smooth surface of hard dental tissue as a white spot lesion due to different refractive index (RI) of sound and dementalized enamel, resulting in highly unpleasant appearance, especially in the anterior zone [1]. White spot lesions occur due to an imbalance in demineralization and remineralization processes that precedes the presence of early caries in enamel [2]. The high porosity of affected hard dental tissue allows air penetration within the enamel structure, causing alteration in optical properties of the tooth surface, that occur due to the dissimilarity in the refractive index between particles of hydroxyapatite and natural gases, which are 1.62 and 1.00, respectively [2].

Enamel translucency and underlying dentin determine the color of the tooth, which varies from yellowish white to grayish-white. The presence of white spot lesions (WSL) affects enamel translucency, primarily endorsed to the degree of the mineralization of the enamel structural surface and its mineral content. Active white spot lesion (WSL) is chalky, white, and opaque due. To the fact that the light is scattered predominantly within the lesion body. The scattering of light in such a case is mainly because of the interfaces between substances with different refractive indexes. White spot lesions if left untreated or neglected may result in the progression to cavities and major esthetic problems [2].

Few techniques have been proposed to esthetically camouflage white-spot lesions or even treat; the common treatment chosen for WSL's involves improving remineralization through CPP-ACP (Casein Phosphopeptide-Amorphous Calcium Phosphate) or products that contain fluoride, as well as restorative procedures, micro-abrasion, and improving using a laser [3]. Excellent esthetic results have been also achieved using therapeutic techniques such as resin composite, and ceramic materials [4]. However, mentioned techniques are known to be associated with excessive sound dental and hard tissue loss. Due to the reversible nature of WSL's, less invasive methods of conservative approach are generally preferred [5]. Among treatment routes, resin infiltration has shown to be a conservative non-invasive predictable treatment that improves dentate esthetics [6]. Although numerous techniques are reported for complete elimination or masking, no consensus was established regarding the ideal protocol [7].

Low-viscosity resin Infiltration into porous lesion body offers a new approach to treat initial interproximal and smooth surface lesions [8]. Resin infiltration has been shown to fill inter-crystalline matrices, altering the light refraction of the WSL's region, thus leading to a similar visual appearance of aesthetic aspects to unaffected dental enamel [9]. However, resin infiltration might affect the teeth' external color and image an appearance that might make teeth look darker [10].

In similar clinical situations, proposed bleaching techniques can be used to overcome such problems [11]. Regarding aesthetics, the main aim of the resin infiltration technique is to conceal the whitish appearance of an affected enamel surface [12]. In mild and non-severe WSL cases, teeth gain a more natural appearance [13].

In an earlier study [14], resin infiltration yielded adequate bleaching outcomes followed by the bleaching association. The fact that resin fills into enamel pores [15] suggests that it may behave as a barrier for the active bleaching ingredient to be in direct contact with enamel will sub-optimize dental bleaching efficiency. However, it is currently unclear whether bleaching agents harm WSLs [16]. Since the infiltrant acts differently in primary and permanent teeth due to differences in the degree of mineralization of each dentition [17], Depending on how deep the resin penetration is, the effect of white spots will differ [18].

Previous studies have reported limitations for the infiltrant to penetrate lesions affected dentin due to the high percentage of water in dentinal contents, which restricts the penetration of hydrophobic resin monomers [5]. In addition, depending on the sorption and solubility of the resinous matrix, the long-term exposure to dyes and acidic solutions may degrade resin through processes of swelling, plasticization, softening, oxidation, and hydrolysis, affecting its color stability [19]. The infiltrant can be stained as a highly hydrophilic material, but its behavior in bleaching procedures is still yet to be studied and observed.

The main objective of this in vitro study is to evaluate the influence of In-Office bleaching material on the color of teeth treated with resin infiltrant. The first hypothesis is that in-office bleaching does not affect the color of the resin infiltration. The second hypothesis is that in-office bleaching does not affect discolored teeth treated with resin infiltration. The third null hypothesis is that discolored resin infiltration is not affected by in-office bleaching.

Materials and Methods

Specimen preparation

Enamel-dentin specimens (N=40) were prepared from extracted human premolars. Roots were separated from the CEJ, leaving a full intact crow using 169 carbide bur, The crowns were then placed in the center of a polyvinyl chloride mold, with the buccal enamel surface facing outward. Molds were filled with self-curing orthodontic acrylic resin leaving only the buccal enamel surface exposed on the spec imen. After sample preparation, the specimens were stored in distilled water at 37C to eliminate dehydration. The specimens were randomly divided into four groups (n=10), All groups underwent a demineralization process and then each group was subject to a specific treatment as shown in **(Figure 1)**.

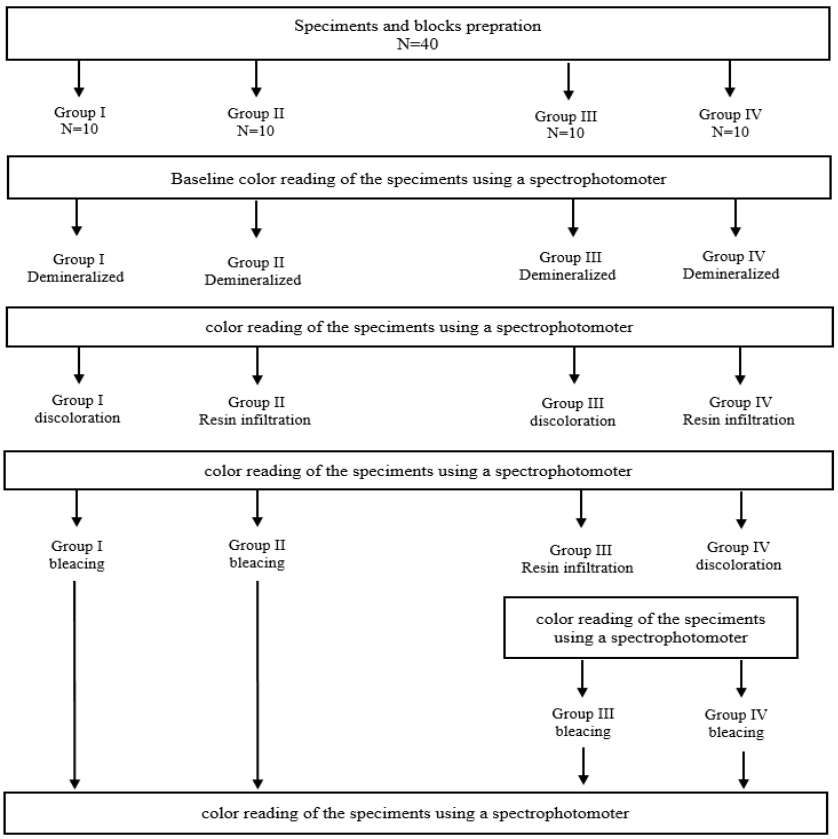


Figure 1. Mapping of materials and methods for all 4 groups

Demineralization process

Artificial enamel subsurface lesions were created on samples by storing specimens in a freshly prepared demineralizing solution for 96 hours. Demineralization Solution composed of 2.2 mm calcium chloride, 2.2 mm monopotassium phosphate, and 0.05 mm acetic acid (pH =4.4) and used 1 mm potassium hydroxide.

Color assessment

To standardize the ambient light amid spectrophotometer measurements, samples were placed in a sample carrier in a light cabin. In the CIE color space, L* indicates light (L+ is light and L- is darkness), the * coordinate embodies red/green (a*+ is red and a*- is green), and the b* coordinate represents yellow/blue range. When a* and b* approach zero, they indicate neutral colors (white and gray) and a greater magnitude for more saturated or intense colors. Based on a cube root transformation of the color data, the L*a*b* color space includes all perceptible colors. The initial color assessment of the specimen (baseline) was conducted with a HunterLab LabScan XE spectrophotometer.

Studying L*, a*, and b* separately provides a better understanding of which coordinate is more responsible for the total color change (DE).

Using the On EZMQC software, the total color change (**Δ**E) was calculated according to the following formula:

$$\Delta E = [\,(L_2^* - L_1^*)^2 + (a_2^* - a_1^*) + (b_2^* - b_1^*)\,]^{1/2} \quad (1)$$

Staining procedure

Extrinsic dietary staining was simulated; specimens were immersed in 100 mL of coffee infusion (Ethiopian Heirloom, Nescafe) containing 8 g of powder per 100 mL boiled water. Direct contact was made between the specimens and the coffee infusion. For 14 days, the procedure was repeated 3 times a day, 15 minutes each time.

Bleaching procedure

In-office bleaching was performed after completing the discoloration process for Group 1 (Control) and Group 4. The same bleaching process was applied after resin infiltration treatment for groups 2 and 3. 40% hydrogen peroxide (Opalescence TM Boost 40%, Ultradent, South Jordan, Utah, USA) was used in this study following manufacturer instructions.

Resin infiltration procedures

Dental milestones guaranteed resin infiltration Icon® resin infiltration (DMG America, Englewood, NJ, USA) was used in this study following manufacturer instructions for groups 2, 3, and 4, First, Icon® Etch, DMG, lasted for two minutes over the WSLs. After that, water was sprayed and the air was blown. A 30-second application of Icon® Dry, DMG, was followed by an air blow. Icon® Infiltrant, DMG, was applied with the provided sponge applicator and left on for 3 minutes. It was subsequently light-cured for 60 seconds.

Statistical analysis

For the test hypothesis, repeated measures ANOVA (rANOVA) was used after normality testing. Multiple comparison tests were followed if the ANOVA p-value was > 0.05. 0.05 was set as the significant alpha level. It was considered significant if the p-value was below 0.05. SPSS was used for statistical analysis (Statistics 25.0 for Windows, IBM SPSS).

Results and Discussion

Group 1 (Control) underwent a baseline reading with a mean of Delta E 4.171, afterward a demineralization process with a mean of 5.008, followed by a discoloration process with a mean of 4.441, and finally, a bleaching procedure proceeding a length of two weeks with a mean of 4.758 **(Table 1, Figures 2 and 3)**.

Group 2 underwent a baseline reading with a mean of 5.949, afterward a demineralization process with a mean of 6.980, followed by a Resin Infiltration process with a mean of 6.078, and finally, a bleaching procedure proceeding a length of two weeks in duration with a mean of 6.007 **(Table 1, Figures 2 and 3)**.

Group 3 underwent a baseline reading with a mean of 6.117, afterward a demineralization process with a mean of 6.836, followed by a discoloration process with a mean of 5.620, then Resin Infiltration process with a mean of 6.575, and finally a bleaching procedure proceeding a length of two weeks in duration with a mean of 6.731 **(Table 1, Figures 2 and 3)**.

Group 4 underwent a baseline reading with a mean of 5.252, afterward a demineralization process with a mean of 5.885, then Resin Infiltration process with a mean of 4.458, followed by a discoloration process with a mean of 2.551, and finally a bleaching procedure proceeding a length of two weeks in duration with a mean of 4.691 **(Table 1, Figures 2 and 3)**.

Table 1. Comparison of Delta E Values Between Baseline, After Demineralization, Staining, and bleaching for all 4 groups

	Reading	N	Mean (Delta E)	Std. Deviation	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Group 1 (Control)	Baseline	30	4.171	1.936	3.448	4.894
	Demineralization	30	5.008	2.203	4.185	5.830
	Stain	30	4.441	4.218	2.866	6.016
	Post-Bleach 2 weeks	30	4.758 *	2.468	3.836	5.680

Group 2	Baseline	30	5.949	2.630	4.967	6.932
	Demineralization	30	6.980	1.977	6.242	7.719
	Resin-Infiltration	30	6.078	2.745	5.053	7.103
	Post-Bleach 2 weeks	30	6.007 **	1.735	5.360	6.655
Group 3	Baseline	30	6.117	2.366	5.234	7.001
	Demineralization	30	6.836	3.249	5.623	8.050
	Stain	30	5.620	3.579	4.283	6.956
	Resin-Infiltration	30	6.575	2.581	5.611	7.538
	Post-Bleach 2 weeks	30	6.731 ***	3.091	5.577	7.885
Group 4	Baseline	30	5.252	2.461	4.333	6.171
	Demineralization	30	5.885	2.183	5.069	6.700
	Resin-Infiltration	30	4.458	1.946	3.731	5.185
	Stain	30	2.551	1.677	1.925	3.177
	Post-Bleach 2 weeks	30	4.691****	2.103	3.906	5.476

*: [Group 1] demonstrates an increase of total mean post bleaching procedure.
**: [Group 2] demonstrates a constant value pre/post bleaching procedure.
***: [Group 3] demonstrates an increase of total mean post bleaching procedure.
****: [Group 4] demonstrates a significant increase post bleaching procedure.

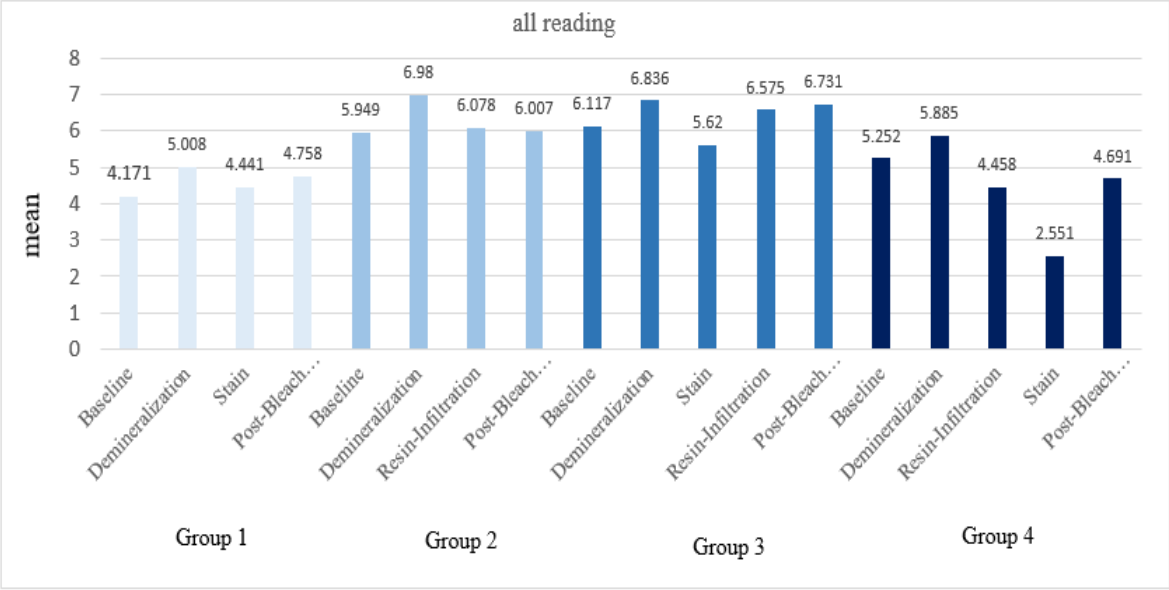
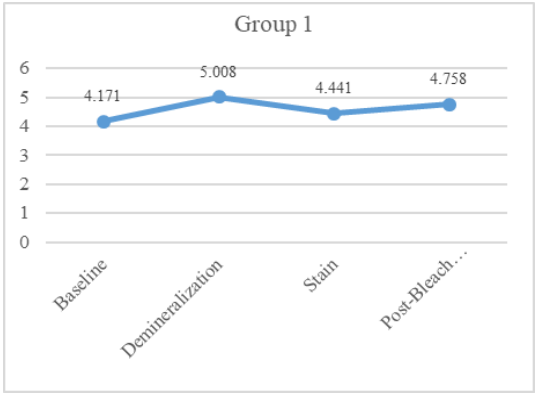
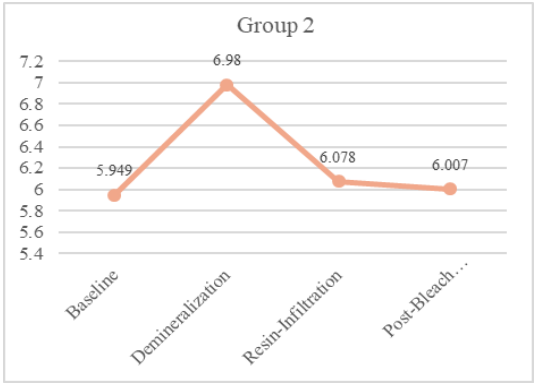


Figure 2. Comparison of Delta E Values Between Baseline, After Demineralization, Staining, and bleaching for all 4 groups.



a)



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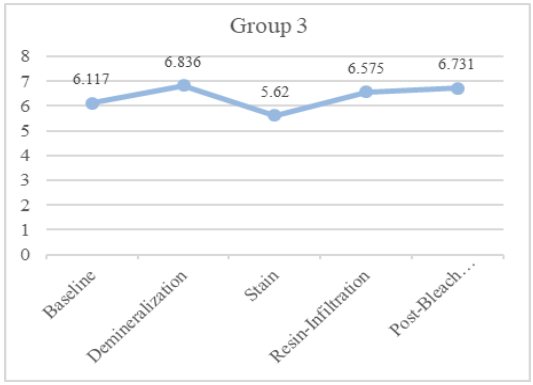

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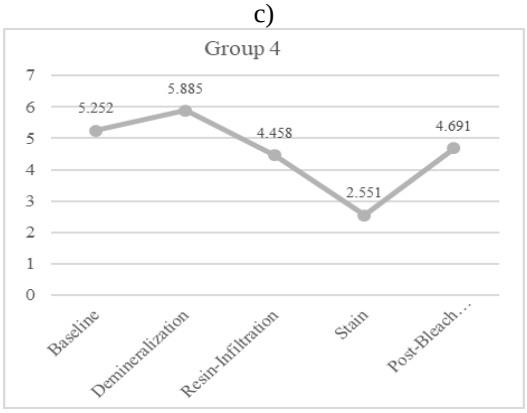

d)

Figure 3. Progression of Delta E Values Between Baseline, After Demineralization, Staining, and bleaching for each group.

There has been increasing use of resin infiltration to treat white spot lesions due to its capacity to reduce caries lesion progression and mask its whitish appearance [20]. Since ICON resin can infiltrate, little is known about the effect of bleaching on teeth treated with resin infiltration. The resin's infiltration capacity might act as a barrier to the penetration of bleaching gel [21]. This study has shown that the impact of bleaching on teeth treated with resin infiltration ICON can penetrate through the resin reaching tooth surface with the presence of stain; with this being said, an approach of the bleaching process within WSL treated with resin infiltration can be made with reasonably expected bleaching effectivity and a significant approach for stained tooth surfaces with resin infiltration rather than removing the resin infiltrated surfaces prior bleaching. Comparing the DE values of Icon infiltrated enamel and sound enamel showed similar results after bleaching. Based on these results, it appears that it is possible to increase the brightness of enamel infiltrated with Icons, eliminating the need for polishing procedures. According to Borges and others [22], demineralized enamel exposed to coffee and wine showed significant staining, which is reliable with the outcomes of this study. The conclusions of this study suggest a more conservative procedure: bleaching. There is no evidence that bleaching promotes enamel removal. Taking into account the results presented in this study, When demineralized enamel treated with resin infiltration was bleached with carbamide peroxide, its DE values were statistically similar to those in the control group and showed no significant difference due to the sample size factor which different results can be obtained by increasing it; nevertheless, our first null hypothesis is that The resin infiltration's color is not affected by in-office bleaching is accepted even though there is a certain degree of increase within the means of the samples but with no significant change, that applies as well to our second and third null hypotheses. However, a single group (Group 4) showed a significant difference after demineralization, after resin infiltration process, after staining procedure, and the final bleaching indicating the presence of bleaching effect on the resin infiltrated teeth surfaces. All values show a sudden increase to the means post bleaching but with no significant value. As a positive bleaching response was observed, we reject our null hypothesis. However, the complexity of treatment procedures, prolonged time, and ambiguity in the treatment of complex cases still constitute challenges for future management. More effective approaches still need to be investigated.

Conclusion

Within the limitation of this study, Depending on the degree of tooth pigmentation, carbamide peroxide gels may act as a semipermeable barrier for resin infiltration. Pigmentation for low vs. high tooth positive bleaching response was observed.

Limitations

An increase in the sample size of each group indicates a further analytic view regarding significant mean values that would aid in future studies for the effect of in-office bleaching concerning resin infiltrated teeth surfaces.

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Conflict of interest: None

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Ethics statement: The research project was submitted to the IRB at King Saud University and it was reviewed and approved on 24 December 2020 project NO. (E-20-5534).

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