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Esthetic Improvements of Various Degrees of White Spot Lesion Using Resin Infiltration and Micro-Abrasion (An *In Vitro* Study)

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ABSTRACT

Background: White spot lesions are esthetic problems caused by subsurface enamel demineralization that seen as white opacity.

Aim of the study: This study aimed to evaluate and to compare the color change after the treatment of the white spot lesions with resin infiltration and micro abrasion.

Materials and Methods: Artificial white spot lesions were generated on 48 premolar teeth by the use of a demineralization solution. The teeth were randomly divided using the Diagnodent into three study groups (16 teeth for each group) depending on the depth of the induced lesions: outer enamel, inner enamel and outer dentine. Then each group was fatherly subdivided into two groups (8 teeth for each group) the first group was treated with resin infiltration, while the second one was treated with micro abrasion. For each group, Spectrophotometric examination was performed at three points: baseline (T0), after producing the lesion (T1), and after the treatment (T2).

Results: While the mean of ΔE between (T0-T1) showed a significant difference between the outer and the inner enamel, the outer enamel and the outer dentine, there was no significant difference between the inner enamel and the outer dentine. On the other hand, the mean of ΔE between (T1-T2) of the three layers of the lesions showed that there was no significant difference between all the layers when the resin infiltration was used. However, there was a significant difference when the micro abrasion was used. The ΔE between (T0-T2) shows no significant difference between the three layers of the lesions and between the two materials, (p>0.05).

Conclusion: Results of the present study revealed that the deeper the white spot lesion the more the color difference it was, and the resin infiltrates was excellent in improving the color of the lesion with the same effectiveness as the microabrsion was.

Key words: Color change, Micro abrasion, Resin infiltration, White spot lesions

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INTRODUCTION

Children with developing enamel abnormalities are known to have a variety of psychological effects [1]. Poor oral appearance and a sense of being different can have a particularly severe impact on the social relationships and self-esteem in young adults with noticeable problems [2]. The whitish chalky appearance of the white spot lesions could be found due to an optical phenomena induced by the mineral loss in the surface and the sub-surface, which modifies the refractive index and increases the light scattering at the affected area, resulting in increased visible enamel opacity [3].

White tooth discoloration or white spot lesions (WSLs) are the result of demineralization of the crown's smooth enamel surface, which is a main cosmetic problem for most of the patients; it can be found because of a variety of circumstances. Dental fluorosis, early caries opacity and developmental abnormalities can cause white discoloration of the enamel. Other variables that might cause WSLs include poor dental hygiene, xerostomia, and a high caries index. Because these lesions are frequently precursors to enamel caries, dental treatment should be focused on both correcting the appearance and preventing the progression of dental caries [4].

Several studies had been shown that using of fluoride or casein phosphopeptide amorphous calcium phosphate could reduce the WSLs [5]; however, surface hyper mineralization caused by high fluoride concentrations, on the other hand, may inhibit the remineralization and increase the chance of permanent brown organic staining that endangering the esthetic treatment outcome [6].

Resin infiltration, introduced lately, attempts to prevent the progression of the carious lesion via the entry of low viscosity resin into the enamel [7]. The resin blocks the

inter-crystalline gaps and pores in the demineralized enamel, forming a diffusion barrier on the surface and inside the deeper layers of enamel, occluding the paths for acid entry, and therefore blocking the lesions from progressing [8]. It had been proven that the use of the resin infiltration could improve the appearance of the WSLs, making their appearance the same as the sound enamel [7,8]. This is due to that its refractive index is near to that of the sound enamel (1.48, 1.65 respectively), so that its use can completely mask the opaque color of the less severe inactive WSLs and partially mask the appearance of the moderate to severe WSLs [4].

Meanwhile, by the use of micro abrasion, which is a conservative approach that used a mix of chemical erosion and mechanical abrasion could remove up to 0.2 m of the affected enamel surface, that is by the applying pumice and 18 % hydrochloric acid slurry to the tooth surface repeatedly [9]. Micro abrasion improves the appearance of the teeth physically by eliminating the discolored enamel, enhancement of esthetics can also be accomplished by creating a bright and smooth surface with various optical properties (abrasion effect) [10].

This study aimed to evaluate and to compare the color change after the treatment of the white spot lesions with resin infiltration and micro abrasion.

MATERIALS AND METHODS

Samples

Teeth samples consisted of 48 sound human premolar teeth which were selected out of 72 extracted tooth for orthodontic purposes from 12-20 years old patients, the teeth were collected from the Oral Surgery Department/ College of Dentistry/University of Baghdad, different Governmental specialist dental health centres and private dental clinics in Baghdad city. Teeth were preserved for one week in 0.05 % thymol solution (an antimicrobial solution that inhibits the bacterial growth). Then soak in distilled water (DW) until ready to use. A 10X magnifying lens was used to examine the collected teeth and any tooth that met the following exclusion criteria was discarded [11]:

- Presence of internal stains.
- Decalcifications or any developmental defect of the enamel.
- Dental caries
- Dental fluorosis.
- Cracks and defects in the enamel.
- Presence of any filling materials.

Methods

Sample preparation

The teeth were washed, cleaned, and polished with non-fluoridated pumice slurry (PD, Switzerland) using one prophylaxis brush mounted to a low speed hand piece (W&H, Austria) to eliminate soft tissues, debris, and calculus. A 6mm adhesive tape circle was carefully placed on the buccal surface of the tooth, and the remaining surfaces of the teeth were coated with an acid resistant nail polish followed by the removal of the adhesive tape, leaving a circular opening on the buccal surface of the tooth (Figure 1) [12].

Figure 1: Preparation of a circular area on buccal surface of permanent premolar.

Formation of WSLs

All of the teeth were soaked, for a whole day, in an artificial caries solution (pH of 5 at 37°C) following the formula given by Corry et al. in 2003 [13]. The demineralizing solution was changed on a daily basis until the frosty white appearance was achieved, for a total period of 15 days [14]. DIAGNOdent ® was utilized to detect the degree of demineralization after the WSL was seen with the naked eye. The extent of the white spot lesion was assessed daily with a DIAGNOdent pen. If the extent of the lesion was not sufficient, the teeth would be immersed in the artificial caries solution again.

According to the DIAGNOdent's readings, the teeth were divided into three groups, 16 tooth for each group [15]. The teeth had been labelled and numbered as followed:

- Group 1: Induced WSL at the outer enamel surface when the readings ranged from 6 to 14.
- Group 2: Induced WSL at the inner enamel surface when the readings ranged from 15 to 20.
- Group 3: Induced WSLs in the outer dentine that did not show any evidence of cavitation ranged from 21 to 29.

Following the demineralization, the specimens were properly washed in distilled deionized water (DDW), the nail polish was removed with acetone, and the teeth were cleaned in DDW once more [12].

Treatment groups after WSLs formation

Each of the three groups, of the teeth with induced WSLs, were randomly subdivided into two groups, each group of 8 teeth, which were treated by either one of the following:

- Resin infiltration (Icon) group: resin infiltration was applied to the induced white spot lesions according to the manufacturer's instructions by which a 15 % HCl (Icon etch; DMG, Hamburg, Germany) was applied for 2 minutes. Then the material was rinsed with water for half a minute before air-drying. After that, the lesion was treated with 99 % ethanol (Icon Dry) for half a minute and air-drying. Infiltrate material (Icon) was utilized, using a micro-brush, and left to be set on the tooth surface for 3 minutes, a cotton roll was used to wipe away any excess of the resin material before the light curing for one minute and ten seconds. A second layer of the infiltrant had been applied that had been let to be set for one minute before the light curing for one minute and ten seconds.
- Micro abrasion (Opalustre Enamel Micro abrasion Slurry, Ultradent, South Jordan, Utah, USA) group: an abrasive material (Opalustre) was applied once for each tooth surface and by the use of the mechanical friction that was generated using a polishing rubber cup at 500 rpm for 30 to 40 seconds. Then the material was removed using water rinsing and air-drying.

Spectrophotometer assessment

Color change (ΔE) was assessed using VITA Easyshade® Advance spectrophotometer (Zahnfabrik, Switzerland). According to the Commission of International of de l'Eclairage, (CIE lab system), the color of the teeth was described by three parameters: (L, a, and b). Where the L parameter represented the value or the degree of the color lightness in Munsell system ranging from 0 (black) to 100 (white). While the "a" parameter represented the measure of the redness (a>0) or greenness (a<0). Meanwhile, b parameter represented the yellowness (b>0) or blueness (b<0) [10].

For each group, spectrophotometric analysis would be measured at three stages: baseline (T0), after inducing the WSLs (T1), and following the treatment (resin infiltration and micro-abrasion application) (T2). Calibration to the spectrophotometer was performed before each application using the device white table to get rid of any quality deviation of the light that might be resulted from the internal light sources of the room. The calculation would be by the following equation [16-18].

$$\Delta E=[(L1-L2)\ 2+(a1-a2)2+(b1-b2)\ 2]\ ½$$

Statistical analyses

Statistical package for Social Science was performed (SPSS, version 21, Chicago, Illinois, USA). Descriptive statistics was applied as minimum, maximum, mean, standard deviation (SD) and standard error (SE), while the inferential statistics used were Levene test, One Way Analysis Of Variance (ANOVA) and General linear model, the Least Significant Difference (LSD) and Bonferroni post hoc test. The level of significance was set at 0.05 %. Partial eta square Effect size were: small (0.01-0.059), medium (0.06-0.139) and Large >=0.14.

RESULTS

Comparisons of the Color change after WSL formation

In this study, the mean color difference ΔE between the T0 and T1 for the three groups (outer enamel, inner enamel, outer dentine) is shown in Table 1. The highest mean was for the outer dentine followed by the inner enamel, while the least mean was for outer enamel which was with a statistical significance difference between the three groups according to ANOVA test (p value=0.044).

Multiple comparisons of ΔE between the groups revealed a significance difference between the (outer and inner enamel), (outer enamel and outer dentine) the mean difference was (-6.553, -6.649 respectively) while there was no significant difference between the (inner enamel and the outer dentine) with the mean difference (-0.095).

Table 1: Color change between baseline and after WSL development (T0-T1) for each of the three main groups.

Groups	Mean	± SD	± SE	Minimum	Maximum	F	p value	ES
Outer Enamel	21.057	7.017	1.754	10.273	32.305	3.347	0.044 Sig.	0.13
Inner Enamel	27.611	7.693	1.923	14.09	40.663			
Outer Dentine	27.706	9.994	2.498	15.602	47.567			
Total	25.458	8.739	1.261	10.273	47.567			
Levene test=0.611, p-value=0.547 NS								

Color change comparisons following treatment with resin infiltration and micro abrasion

Table 2 displays the mean in the color difference (ΔE) between the three groups after WSLs development compared with that after the treatment with the resin infiltration and the micro abrasion (T1 and T2).

Concerning the treatment with the Icon material, although the outer and the inner enamel treated by the resin infiltration gave the highest mean (32.69 ± 8.95, 32.083 ± 12.342 respectively), the outer dentine gave the least mean 24.93 ± 6.78.

However, statistically there was no significant difference between the three groups (p>0.05), which mean that the Icon material worked effectively in all the three layers after the WSLs development (demineralization process).

On the other hand, the WSLs treated with the opalustre showed that the mean values of the outer and the inner enamel were the higher means (32.08 ± 12.34 and 31.26 ± 4.07 respectively) while the mean value of the outer dentine was 20.87 ± 8.13. Statistically there was a significance difference between the three layers, (p>0.05).

A significance difference was found according to Pairwise Comparisons (Bonferroni) between the outer enamel and the outer dentine, the inner enamel and the outer dentine groups, the mean difference was (11.208, 10.392 respectively) while there was no significant difference between the outer and the inner enamel group with mean difference (0.816).

This means that the opalustre material was more effective in the outer and the inner enamel layers and had the least effectiveness concerning the outer dentine layer.

Table 2: Comparison between the mean of ΔE of the groups of various degrees of WSLs (T1-T2) following treatment with Icon and opalustre.

		ΔE DR				F	p value	Effect size
Material	**Groups**	**Minimum**	**Maximum**	**Mean**	**± SD**			
ICON	Outer Enamel	21.389	48.672	32.692	8.953	1.821	0.174 ^	0.08
	Inner Enamel	11.559	45.77	32.315	11.963			
	Outer Dentine	14.727	31.941	24.934	6.78			
Opalutre	Outer Enamel	19.853	51.935	32.083	12.342	3.716	0.033 *	0.15
	Inner Enamel	22.968	35.458	31.268	4.077			
	Outer Dentine	12.621	36.019	20.875	8.139			

^=not significant at p>0.05, *=significant at p<0.05.

Table 3 displays the mean in the color difference (ΔE) between the three groups at baseline compared with that after the treatment with the resin infiltration and the microabrasion (T0 and T2).

Concerning the treatment with the Icon and opalustre materials, although the outer dentine gave the highest mean and outer, inner enamel gave the least mean in both materials. which mean that, the least color change effect after treatment when compared with baseline was in outer and inner enamel while the highest color change was in outer dentine.

However, statistically there was no significant difference between the three groups (p>0.05).

Table 3: Comparison between the mean of ΔE of the groups of various degrees of WSLs (T0-T2) following treatment with Icon and opalustre.

		ΔE BR				F	P value^	Effect size
Material	**Layer**	**Minimum**	**Maximum**	**Mean**	**± SD**			
ICON	outer Enamel	3.48	19.669	10.294	5.096	1.731	0.19	0.076
	Inner Enamel	3.536	19.932	11.012	6.095			
	Outer Dentine	4.653	22.684	15.396	6.451			
Opalutre	outer Enamel	5.111	14.318	9.57	3.284	0.711	0.497	0.033
	Inner Enamel	2.437	18.058	9.558	5.955			
	Outer Dentine	3.295	26.008	12.629	7.777			

^=not significant at p>0.05

Table 4 reveals a comparison of the mean of the color difference (ΔE) (T1-T2) after demineralization compared with that after the treatment while Table 5 reveals a comparison of the mean of the color difference (ΔE) (T0-T2) at baseline compared with that after the treatment of the WSLs with the resin infiltration (Icon) and the micro abrasion (Opalustre) for the three groups.

Although the mean of ΔE for the three groups treated with the resin infiltration was higher than that found with the groups treated by the opalustre.

However, there was no significant difference between the two materials (p>0.05), which reflecting that both of the materials were effective in masking the color of the WSLs.

Table 4: The mean of ΔE (T1-T2) after demineralization compared with after treatment with Icon and opalustre.

Groups	Material								F	p value^	Effect size
	ICON				Opalutre						
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD			
Outer Enamel	21.389	48.672	32.692	8.953	19.853	51.935	32.083	12.342	0.784	0.381	0.018
Inner Enamel	11.559	45.77	32.315	11.963	22.968	35.458	31.268	4.077	0.052	0.82	0.001
Outer Dentine	14.727	31.941	24.934	6.78	12.621	36.019	20.875	8.139	0.018	0.895	0
^=not significant at p>0.05											

Table 5: The mean of ΔE (T0-T2) after demineralization compared with after treatment with Icon and Opalustre.

Layer	Material								F	P value ^	Effect size
	ICON				Opalutre						
	Minimum	Maximum	Mean	± SD	Minimum	Maximum	Mean	± SD			
outer Enamel	3.48	19.669	10.294	5.096	5.111	14.318	9.57	3.284	3.851	0.056	0.084
Inner Enamel	3.536	19.932	11.012	6.095	2.437	18.058	9.558	5.955	0.297	0.589	0.007
Outer Dentine	4.653	22.684	15.396	6.451	3.295	26.008	12.629	7.777	0.061	0.805	0.001
^=not significant at p>0.05.											

DISCUSSION

Damage that happened before or after tooth eruption might result in an opaque color changes. The most common white enamel lesions that can be seen before teeth eruption are the fluorosis, trauma-induced hypo mineralization, and molar incisor hypo mineralization. WSLs that appear after the eruption of a tooth are initial carious lesions [17]. Those lesions can lead to an aesthetic problem, which are more common in children and young people [18].

The fundamental goal in the treatment of the WSLs is to restrain their progression and to improve the appearance, which can be achieved by the increase in the translucency of the affected opaque lesions [7]. In case of WSLs, the micro porosities that are found on the tooth surface permit pathways for the acids and the dissolved minerals, however, infiltration of dental caries, which is a new simple technique, can arrest the progression of the WSLs by occluding these micro porosities. Lesions that are not progressed to a degree that they need invasive restorative treatment can get benefit from this micro-invasive type for the treatment [19].

Results obtained from the present study revealed that a difference in the initial color of the tooth was found after the development of the WSLs. There was a statistically significant difference when the three groups (outer and the inner enamel, outer dentine) were compared spectrophotometrically, however, there was no significant difference between the inner enamel and the outer dentine. The outer dentine layer showed the highest color difference, indicating that the deeper the WSL, the more ΔE would be. This finding was in consistent with the findings of Abbas et al. (2018), who use a spectrophotometric analysis of the different layers of WSLs; the WSL with the deepest depth had the greatest color difference [18]. Resin infiltration had been proven to inhibit the progression of early carious lesions, which are advanced to be treated with fluoride application [16,20]. The resin utilized in this approach has properties that are so important for the penetration of the resin infiltration to the whole depth of the enamel lesion through the capillary forces. These are related to the viscosity of the material, which is very low, enamel contact angles that are low also, in addition to the surface tension that is high [21,22]. Etching the surface layer with 15% hydrochloric acid had been demonstrated to be efficient that can enable the deeper penetration of the resin infiltration into the whole lesion's body [8]. In comparison to the materials without solvents, resin infiltrates with solvents such as ethanol, acetone, and water have reduced the surface tension, viscosity, and had a greater penetrating coefficient [7]. Regardless of the seal produced by resin penetration, microleakage

related to the polymerization shrinkage had been reported to lead to caries formation [16,21]. Thus, the ability of the infiltrant to penetrate to the depth of the lesion, rather than improving the translucency of the lesion, determines the efficacy of resin infiltration treatment [21].

The effect of the Icon (resin infiltration) in different depths of the demineralized lesions was investigated, and the results revealed that the Icon was more effective when the lesion was in the outer and inner enamel than in the outer dentine, however, there was no statistically significant difference between the layers. This means that the resin infiltration could improve the color of WSLs in the outer, inner enamel, and outer dentine.

The use of the micro abrasion as a treatment for the WSL can aid in esthetic improvement by altering its appearance. Another study, supported this result, advocated that eradication of WSLs can be achieved using the micro abrasion as a treatment modality [22]. Micro abrasion improves the appearance of WSLs by removing the superficial part of lesions by the chemical erosion with hydrochloric acid and the mechanical abrasion with the pumice, resulting in the smoothening and glossing of the lesion [22,23]. According to previous studies, 250 μm of the surface enamel could be removed with the aid of the use of the micro abrasion [16]. As a result, microabrasion might remove the relatively intact outer and inner layers of WSLs, allowing the lesions to come into direct contact with the saliva for the remineralization. In this study, it had been found that after the treatment with opalustre, as a micro abrasion at different depth of WSL, there was a significance difference between the results when treating the outer enamel and the outer dentine. So as that when treating the inner enamel and the outer dentine, while there was no significant difference between the outer and the inner enamel. This indicating that when the depth of WSL increases the material became less effective in masking the color of WSL.

This study compared also the ΔE between the resin infiltration and the micro abrasion, despite that ΔE mean of the resin infiltration was higher than that of the micro abrasion, no significant difference in ΔE was observed between the two groups, indicating that both of the materials were effective in treating WSL and improving its color. This result was in agreement with that of Gu, et al. in 2019 [21].

For the pediatric dentistry, dental drill can be limited by the use of the micro invasive technology, which is an advantage aid in improving the treatment acceptance by the patient. Meanwhile, in a comparison with the application of the fluoride, it is a procedure that can be finished in a single sitting that will prevent the periodic recall of the child patient. There is no need to prepare a cavity in treating the newly carious lesion by the use of this new modality of treatment, thus will protect and fully preserve the sound hard tissue that surrounding the carious lesion. Furthermore, virtually this technique is painless as its use does not need an anesthesia and the duration of the treatment can be predicted, thus favourably affects the treatment acceptance of the pediatric patients [23,24].

CONCLUSION

The color of the lesion become more opaque as the WSL advanced, leading in a higher color difference. Both of the two materials (resin infiltration and micro abrasion) were effective as a non-invasive treatment for masking the color of the WSLs, especially for the outer and the inner enamel, while in the outer dentine, resin infiltration found to be more effective than the micro abrasion.

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