

EFFECT OF PREHEATING AND ULTRASONIC ENERGY ON PENETRATION OF LOW VISCOSITY ENAMEL RESIN INFILTRANT

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ABSTRACT

Objectives: to determine the depth of resin infiltrated hybrid enamel after application of TTEMA/TEGDMA resin infiltration agent enriched with nano-hydroxy apatite applied on early carious enamel lesions.

Materials and Methods: Sound maxillary centrals were coated with a nail varnish, leaving a window of 4 mm × 4 mm on buccal surface of sound and intact enamel. All specimens were subsequently immersed in a demineralizing solution to produce artificial enamel lesions then etched with a mixture of 2% chlorhexidine and 10% hydrochloric acid. After washing and drying the enamel was coated with a low viscosity TTEMA/TEGDMA resin infiltration agent followed by light polymerization. The effect of addition of 10% nano-hydroxy apatite, preheating at 45°C, and ultrasonic activation was tested in separate groups. Sectioned specimens were examined under a stereomicroscope equipped with a high-resolution digital camera for determining of the depth of penetration of the low viscosity resin in microns ($\alpha=0.05$).

Results: Data analysis revealed significant difference in depth of enamel hybrid layer between the tested groups ($F=14.2$, $P<0.001$). Average penetration depth was $185 \pm 17 \mu\text{m}$ for TTEMA/TEGDMA resin infiltration agent. Addition of 10% nano-hydroxy apatite reduced penetration depth to $141 \pm 19 \mu\text{m}$. On the contrary, preheating and ultrasonic activation increased penetration depth to $211 \pm 13 \mu\text{m}$ and $221 \pm 12 \mu\text{m}$ respectively.

Conclusions: Within the limitations of this study, the penetration depth of TTEMA/TEGDMA resin infiltration agent was significantly influenced by addition of nano-hydroxy apatite particles. Preheating and ultrasonic activation increased penetration depth significantly.

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INTRODUCTION

White spots are among the most frequent dental aesthetic impairment affecting enamel. Despite of being non-cavitated carious lesions, white spots may be associated with fluorosis, post-traumatic lesions, and molar incisor hypomineralization. Common for all these defects is increased porosity of enamel resulting in change of its reflective index. White spots are associated with accumulation of plaque and its bacterial activity that reduces oral pH rendering it acidic resulting in progressive demineralization of enamel.⁽¹⁻³⁾

The progression of white spot lesions can be slowed or even arrested by non-operative measures such as using a remineralizing toothpaste, avoiding acidic foods, and getting sufficient supplements of vitamin D.⁽⁴⁾ The most important strategy is to prevent further demineralization and biofilm formation. Alternative methodologies include lesion thinning, micro abrasion, erosion-infiltration, adhesive composite resin restorations, and bonded laminates for progressive cases.^(5,6) Topical fluoride is considered as the best anticariogenic agent in dental practice. However studies have showed that the long term application of fluoride may cause discoloration.⁽⁹⁾ Others showed that treatment with fluoride or casein-phosphopeptide amorphous calcium phosphates (CPP-ACP) enhanced remineralization^(10,11) but revealed no significant effect regarding esthetics.⁽¹⁰⁾ Enamel microabrasion with hydrochloric pumice reduced the appearance of white spots but caused further loss of enamel surface minerals.⁽¹⁰⁻¹²⁾

Although lesions can be arrested by these measures they still continue to pose esthetic problems referred to as “enamel scars”.² At times, these measures may not be effective and the carious lesions tend to progress. In such conditions, the infiltration of carious lesions with low viscosity light polymerized resins is considered as a treatment option for non-cavitated lesions.³ This technique aims to penetrate the porous enamel with low viscosity light polymerizing resins known as infiltrants. When the resin is light polymerized,

it blocks the diffusion pathways and protects the remaining apatite crystals. One positive effect of resin infiltration is an immediate color change of the whitish lesion as the infiltrate resin has a refractive index of 1.52, which is close to that of enamel, 1.62. Therefore, light scattering between the enamel pores and the surrounding enamel is significantly reduced when the pores are filled with resin instead of water or air. Under the best conditions, the resin-infiltrated lesions are optically masked and eventually “disappear”.^{4,5}

Previous clinical studies have focused mainly on the clinical success and outcome of the resin infiltrants. However, reaching the maximum depth of resin penetration would be the key factor for infiltration success and creating an effective diffusion barrier. Hence, the aim of the present study was to determine the penetration depth of TTEMA/TEGDMA resin infiltration agent enriched with nano-hydroxy apatite using two methods of activation.

MATERIALS AND METHODS

40 healthy, sound anterior maxillary centrals were collected and stored in demineralized water at 37°C. The specimens were washed, dried, and coated with acid resistant nail varnish, leaving a 4 mm × 4 mm window on the buccal surface. A demineralizing solution was prepared by mixing 50 mM acetic acid + 2.2 mM Ca(NO₃)₂·2H₂O + 2.2 mM KH₂PO₄ + 0.1 ppm NaF while maintaining a pH between 4.2 and 4.25 by adding refreshing amounts of 10% HCL solution. Teeth were immersed in the demineralizing solution for 3 days. Solution was freshened daily. After 3 days the teeth developed white spot lesion when air dried.

Application of enamel infiltration agent

The surface of the artificially created white spot was etched with a mixture of 2% chlorhexidine and 10% hydrochloric acid gel for 2 min. The teeth were finally washed and dried. Low viscosity TTEMA/TEGDMA resin infiltration was prepared by first preparing Tris[4-(2'-hydroxy-3'-methac-

ryloyloxypropoxy) phenyl]methane (TTEMA) by mixing triphenylmethane triglycidyl ether (TTE) with methacrylic acid (MA) in the presence of 4-(dimethylamino)pyridine. 50% TEGDMA was added to the mixture with 0.1% photo initiator.

The teeth were divided into four groups where the prepared infiltrant was either directly applied on white spot lesions or after addition of 10% nano-hydroxy apatite particles (100-140 nm) suspended in 99% ethanol. The effect of preheating the infiltrant to 48°C and the effect of application of ultrasonic activation using a stainless steel application tip were investigated. The excess material was removed using blot drying and the surface was light polymerized for 40 seconds.

Examination of penetration depth

The specimens were stained using 10% sodium fluorescein and sectioned into two halves along the bucco lingual plane using a precision cutting machine (Micracut 150 precision cutter, Metkon, Bursa Turkey). All the specimens, were then observed under a stereomicroscope (Olympus BX 61, Hamburg, Germany) equipped with a high-resolution digital camera (E330, Olympus, Imaging Corp, Beijing, China) for determining the depth of penetration of the low viscosity resin in microns. The penetration depth measurements were made as the distance from the surface of the specimen to the end of dark area of the enamel which indicates the end of resin penetration and the maximum and minimum values were considered. Data were analyzed using one way analysis of variance ($\alpha=0.05$).

RESULTS

Data analysis revealed significant differences in depth of enamel hybrid layer between the tested groups ($F=14.2$, $P<0.001$). Average penetration depth was $185 \pm 17 \mu\text{m}$ for TTEMA/TEGDMA resin infiltration agent. Addition of 10% nano-hydroxy apatite reduced penetration depth to $141 \pm 19 \mu\text{m}$. On the contrary, preheating and ultrasonic activation increased penetration depth to $211 \pm 13 \mu\text{m}$ and $221 \pm 12 \mu\text{m}$ respectively, Figure 1.

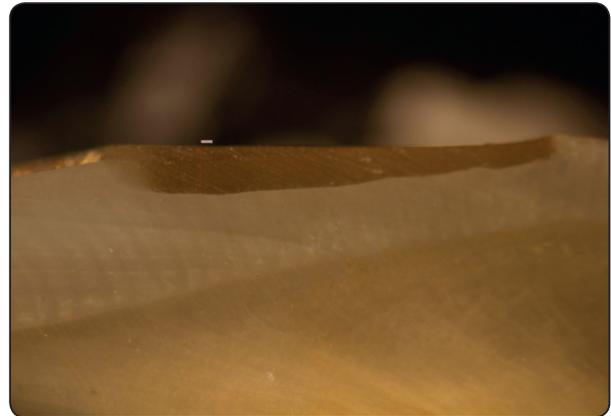


Fig. (1-A) Resin infiltration of early enamel lesion using low viscosity infiltrant. Almost one fifth of enamel thickness was penetrated by the infiltrant.

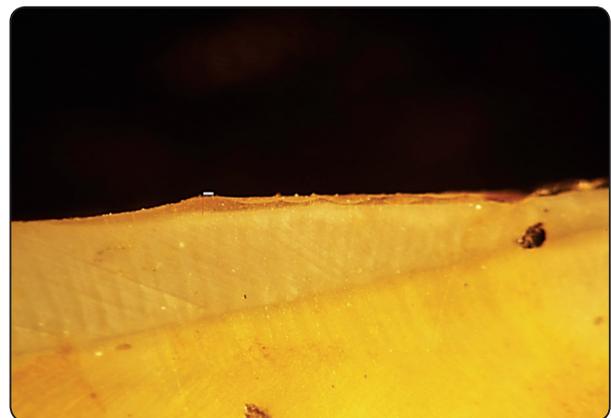


Fig. (1-B) Addition of nano-fillers reduced penetration capacity of resin infiltrant.

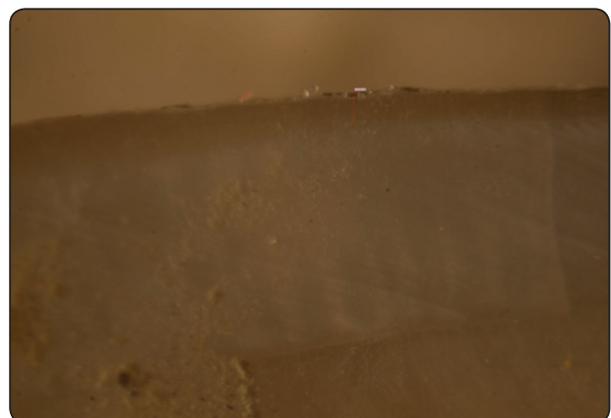


Fig. (1-C) Preheating of calcium phosphate enriched enamel infiltrant improved penetration depth.

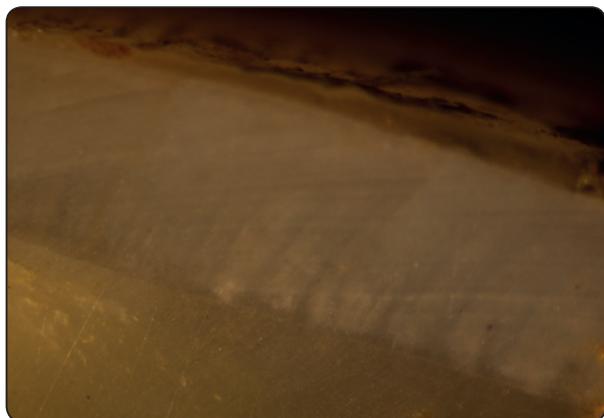


Fig. (1-D) Ultrasonic activation calcium phosphate enriched enamel infiltrant improved penetration depth of white spot lesion in enamel.

DISCUSSION

Resin infiltration has a distinctive benefit which is its ability to modify white spots appearance without excessive loss of sound dental hard tissue. However, micro-structural changes in enamel rods as microcracks and fractures were already reported.¹³ Several trials focused on increasing penetration depth of the enamel infiltrants as application of a bleaching agent¹⁴ or different enamel conditioners as hydrochloric acid, sodium hypochloride, and chlorhexidine.¹⁵ Application of enamel etching agent and increasing application time both resulted in increasing penetration of enamel infiltrants.¹⁶

Application of acidic etching agents are known to enhance micro-porosity of enamel, however, low concentration of hydrochloric acid is known to reduce mineral loss compared to phosphoric acid. Reducing the viscosity of the infiltrants by addition of low molecular weight monomer as TEGDMA has a great beneficial effect in this application allowing deeper penetration depth. In combination with low molecular weight of TTEMA, penetration depth of enamel infiltrants can be greatly enhanced.

Addition of 10% nano-hydroxy apatite may improve mineral uptake from enamel infiltrants but this has to be weighed against the reduced penetration

depth. Further studies are needed to elaborate on calcium ion exchange across resin infiltrated enamel lesions. Using nano-particles as a drug delivery tool or incorporation of amorphous forms of calcium phosphate may enhance remineralization across infiltrant-enamel interface. Preheating and ultrasonic activation both significantly enhanced penetration depth of the enamel infiltrant by simply reducing its viscosity and enhancing capillary action. Preheating technique was previously tested to enhance adaptation of high filler content resin composite. Newly released ultra-sonic activation devices enhanced delivery and adaptation of packable resin composite in complicated cavity designs. Similar findings were observed when used with low viscosity infiltrants. Several studies focused on evaluation of penetration depth of different types of infiltrants. Average penetration depth ranged between xxxx and xxxxx which is relatively lower than the values reported in the current study. Deeper penetration depth indicates more efficient treatment of white spot lesions.

CONCLUSION

Penetration depth of TTEMA/TEGDMA was improved using ultrasonic activation and preheating of the infiltrants.

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