

Resin Infiltration of Artificial Enamel Lesions: Evaluation of Penetration Depth, Surface Roughness and Color Stability

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ABSTRACT

Aim: To evaluate the penetration depth, surface roughness, and color stability of resin infiltration restoration of artificial enamel lesions induced in primary and permanent teeth.

Materials and methods: Primary (group I, $n = 30$) and permanent (group II, $n = 30$) extracted non-carious human anterior teeth were subjected to demineralization for four days after creating a window of 5 mm × 5 mm on the labial surfaces. Demineralized area was infiltrated with the low viscosity resin. Ten samples from each group were evaluated for penetration depth, surface roughness, and color stability, respectively. Penetration depth was determined using a stereomicroscope at 80× magnification. Surface roughness of sound and infiltrated enamel was recorded using a profilometer. The color stability was assessed at 2, 4, and 8 weeks along with baseline values using vita easy shade spectrophotometer.

Results: Data were analyzed using the student “*t*” test and Friedman test. The degree of resin penetration was observed to be higher in primary teeth ($32.6 \pm 15.72 \mu\text{m}$) compared to permanent teeth ($24.23 \pm 6.85 \mu\text{m}$), but no significant difference was found ($p = 0.138$). Surface roughness values of resin infiltrated enamel is similar to that of sound enamel in both primary ($p = 0.617$) and permanent teeth ($p = 0.234$). The mean color stability scores immediately after resin infiltration at 2, 4, and 8 weeks intervals showed no statistically significant difference in primary ($p = 0.998$) and permanent teeth ($p = 0.213$).

Conclusion: Resin penetration into enamel lesions was more in primary teeth enamel compared to permanent. The early enamel lesions, when treated with resin infiltration, showed surface characteristics similar to sound enamel and also exhibited acceptable color up to 8 weeks duration.

Clinical significance: Resin infiltration can be considered as an effective and predictable treatment option for the restoration of early enamel lesions owing to its deeper penetration, provision of better surface characteristics, and reliable masking of white spot lesions in both primary and permanent dentitions.

Keywords: Dental restoration, Icon infiltrant, White spots.

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INTRODUCTION

White spot lesions on enamel surfaces are the early signs of demineralization, which may or may not lead to the development of caries. These lesions should be diagnosed early; otherwise, it may lead to extensive enamel break down. An established white spot lesion has a chalky and opaque appearance, and this whitened characteristic appearance is because of increased superficial porosity of the enamel by cariogenic acids.

Treatment options for such enamel lesions include remineralization using various fluoridated and non-fluoridated remineralizing agents. The outcome of this option is always unpredictable, as their effect is superficial. Therefore, the deeper lesions do not remineralize completely, as the formation of a hypermineralized surface layer hampers the remineralization of the subsurface lesion body.¹ Hence, there is a quest for a material/technique that could address the effective management of these early enamel lesions.

A novel technique called resin infiltration restoration has been introduced to inhibit the progression of these lesions. However, there is limited information available regarding the penetration depth, surface roughness, and color stability of such restorations in primary teeth. Hence, a study was carried out to evaluate the penetration depth, surface roughness, and color stability after resin infiltration of artificially created enamel lesions in primary and permanent teeth.

MATERIALS AND METHODS

The study design was approved by the Institutional Review Board. A total of 30 primary (group I) and 30 permanent (group II)

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extracted non-carious human anterior teeth were collected and sterilized as per the Centers for Disease Control and Prevention (CDC) guidelines.² Ten samples from each group were evaluated for penetration depth, surface roughness, and color stability, respectively. All the samples were coated with nail varnish, leaving a window of 5 mm × 5 mm on the labial surface. A demineralizing solution was prepared using 2.2 mM calcium chloride, 2.2 mM monopotassium phosphate, 0.05 mM acetic acid having pH adjusted to 4.4 and 1 M potassium hydroxide, and all the samples were immersed in this solution for four days to create artificial white spot lesions.³ Then the demineralized area was infiltrated with the low viscosity resin (ICON; DMG, Hamburg, Germany) as per the manufacturer’s instructions.

Method of Application of Low Viscosity Resin

The surface of artificially created white spot lesion was etched for 2 minutes using 15% hydrochloric acid gel (Icon etch™). Subsequently, the etching gel was thoroughly washed for 30 seconds using a water spray. Then the lesion was desiccated by applying ethanol (Icon-Dry™) for 30 seconds and air-dried. Low viscosity resin was applied on the lesion surface using a microbrush and was allowed to penetrate for 3 minutes and light-cured for 40 seconds. Again the infiltrant application was repeated, allowed to penetrate for 1 minute, and then light-cured.

Evaluation of Penetration Depth

For determining the penetration depth, teeth were immersed in methylene blue dye for 24 hours at 37°C. Samples were then sectioned longitudinally into two halves and observed under stereomicroscope at 80× magnification. Stereomicroscopic photographs were taken using Image pro plus software, and the depth of infiltrant was measured in microns.

Evaluation of Surface Roughness

Surface roughness of sound enamel (baseline) and that of infiltrated enamel was recorded with a noncontact 3D optical profiler using the arithmetic mean of the sum of roughness profile values (R_a). The average of three readings was measured in mm.

Evaluation of Color Stability

The color of the specimens was measured with Vita easy shade advance spectrophotometer by means of the CIELAB (Commission International de L'Eclairage L^*a^*b) color notation system. The baseline evaluation of all the samples was made by means of quantitative measurement of lightness (parameter "L") and color of the test specimens [parameters a^* (red/green) and b^* (yellow/blue)]. To standardize color evaluation, care was taken as follows: standardization of the room lighting by using a daylight bulb; specimens were placed against a white background during all readouts; standardization of the tip of the spectrophotometer appliance (vertical position, totally supported on the test specimen); marking of test specimens to allow readouts always to be taken in the same position. The color readouts were repeated immediately after the resin infiltration and after 2, 4, and 8 weeks of immersion in artificial saliva. Thus, the parameters "L", "a", and "b" were obtained at different time intervals for all the samples. For each specimen,

the parameters "L", "a", and "b" were obtained at different time intervals. Therefore, the quantitative evaluation of the variation in lightness (ΔL) and color (ΔE) of the test specimens was obtained by means of the following formulae: $\Delta L = L_1 - L_2$, where L_1 is the lightness measured at time 1 and L_2 the lightness measured at time 2; and ΔE (total color difference value) = $[(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$.

The obtained data was statistically analyzed using parametric tests paired t test for intragroup comparison and unpaired t test for intergroup comparison and a nonparametric Friedman test for intragroup comparison to evaluate the color stability. A probability value of $p \leq 0.05$ was set for statistical significance and a value of $p \leq 0.000$ for statistically highly significant relation.

RESULTS

The obtained results inferred that the depth of resin penetration was more in primary teeth ($32.6 \pm 15.72 \mu\text{m}$) than the permanent teeth ($24.23 \pm 6.85 \mu\text{m}$), but the difference is not statistically significant ($p = 0.138$) (Table 1). There is no significant difference between the surface roughness of sound enamel and resin infiltrated enamel in both primary ($p = 0.617$) and permanent teeth ($p = 0.234$) (Table 2). The differences in mean color stability scores immediately after resin infiltration at 2, 4, and 8 weeks intervals are statistically not significant both in primary teeth ($p = 0.998$) and permanent teeth ($p = 0.213$) (Table 3).

DISCUSSION

The first clinical sign of dental caries is the formation of white spot lesions on the enamel. Depending on the site-specific state of caries activity, the lesion may tend to progress (active lesion) or stagnate or regress (inactive lesion).⁴ According to the clinical evidence, the risk of cavity formation is substantially higher for active lesions than for inactive lesions.⁵ Management of these lesions is indicated to arrest the lesion progression and improve the esthetics by diminishing the opacity. Traditional nonoperative measures include the remineralization by using various fluoridated or non-fluoridated remineralizing agents. However, lack of patient compliance and neglect in oral hygiene makes this measure not effective at times, and carious lesions tend to progress.

Table 1: Intergroup comparison of mean penetration depth of resin infiltrated groups

Parameter	Groups	Sample size (n)	Mean ± SD	Unpaired t value	p value
Penetration depth	Group I, primary	10	32.6 ± 15.72	1.553	0.138 (NS)
	Group II, permanent	10	24.23 ± 6.85		

Unpaired t test; NS, not significant

Table 2: Comparison of mean surface roughness values of sound and resin infiltrated enamel of primary and permanent teeth

Type of specimen	Sample size (n)	Mean ± SD	Paired t value	p value
<i>Group-I (primary teeth)</i>				
Sound enamel	10	0.25 ± 0.19	0.518	0.617 (NS)
Resin infiltrated enamel	10	0.25 ± 0.18		
<i>Group-II (permanent teeth)</i>				
Sound enamel	10	1.43 ± 2.04	1.275	0.234 (NS)
Resin infiltrated enamel	10	1.29 ± 1.99		

Paired t test; NS, not significant

Table 3: Comparison of mean color stability scores of resin infiltrant in primary and permanent teeth at different intervals

Intervals	Samples (n)	Mean \pm SD	F value	p value
<i>Group-I (primary teeth)</i>				
Immediate	10	4.8 \pm 0.6	0.013	0.998 (NS)
2 weeks	10	4.78 \pm 0.6		
4 weeks	10	4.78 \pm 0.4		
8 weeks	10	4.76 \pm 0.3		
<i>Group-II (permanent teeth)</i>				
Immediate	10	4.7 \pm 2.1	1.934	0.213 (NS)
2 weeks	10	4.6 \pm 2.1		
4 weeks	10	4.6 \pm 2.0		
8 weeks	10	4.5 \pm 2.0		

Friedman test; NS, not significant

Resin infiltration technique, a novel concept in minimally invasive dentistry, is introduced to overcome the unpredictable outcomes with remineralizing agents. This material acts by occluding the pores of the demineralized lesion body by capillary forces. The infiltrated white spot lesions appear to be similar to the surrounding enamel because of the negligible difference in the refractive indices between the sound enamel (RI = 1.62) and infiltrant resin (RI = 1.46).⁶

The partially mineralized intact surface layer impedes the penetration of the resin into the lesion body. The application of 15% hydrochloric acid gel supplied by the manufacturer has been demonstrated to be effective in removing the surface layer of natural enamel lesions when applied as an etchant for 2 minutes.⁷ Application of ethanol (99% alcohol, Icon-dry) removes the moisture inside the microporosity of the lesion body and allow the resin to penetrate by capillary forces.⁸ Subsequent application of the resin for two times is considered to compensate polymerization shrinkage and fill the porosities and crevices within the infiltrated lesion.⁹

The observations of the present study confirm that the penetration depth of infiltrant resin is more with primary teeth enamel compared to permanent teeth enamel. The difference is attributed to structural differences such as mineralization and the presence of aprismatic layer in the enamel of the primary teeth. In accordance with this fact, Turska-szybką et al. demonstrated that when the resin is infiltrated in natural carious lesions on primary molars, the maximum penetration depth of 182.2 μ m was noticed,¹⁰ whereas when premolars were infiltrated with resin, only 6.06 μ m penetration depth is noticed.¹¹

Restoration with low surface roughness provides a high-quality surface, which prevents the formation of discoloring films and avoids plaque accumulation. Rough surface enhances bacterial adhesion and increases the risk of demineralization. The results of the study demonstrated that there was no difference in the surface roughness (R_a) of resin infiltrated enamel and sound enamel in both primary and permanent teeth. Similar observations were reported by Burgess et al. as well as Taher et al., where they found that caries infiltration did not lead to an increased surface roughness of infiltrated lesions compared to sound enamel.^{12,13}

Esthetic restorative materials should have good color stability. Otherwise, esthetics is compromised when it gets exposed to the dynamic environment in the oral cavity due to the presence of microflora, saliva, and frequent intake of colored food and beverages, which then becomes a challenging task to dental

experts. The present study demonstrated good color stability of the resin infiltrated enamel when evaluated after 2, 4, and 8 weeks with no significant difference in both primary and permanent teeth. Similarly, Yuan et al. reported that resin infiltration maintained color stability when evaluated after six weeks of application.¹⁴

The outcomes of this study infer that white spot lesions can be infiltrated satisfactorily to mask the topographical alterations of demineralized enamel as well as to restore and maintain the natural color of enamel in both primary and permanent teeth. Proper infiltration depends on excellent moisture control, which is undoubtedly easier in *in vitro* conditions. The extrapolation of these results to clinical conditions must be exercised with caution, as the surface roughness and color stability may differ due to the dynamic complex biological systems.

CONCLUSION

Based on the observations of the present study, following conclusions were drawn:

- The depth of resin penetration was more with enamel lesions of primary teeth compared to permanent teeth.
- Resin infiltrated enamel did not show alteration in surface roughness compared to the sound enamel.
- Resin infiltrated enamel showed color stability over eight weeks duration.
- Resin infiltration can be considered as an effective treatment modality for the restoration of early enamel lesions owing to its good penetration property, provision of better surface characteristics, and reliable masking of white spot lesions in both the dentitions.

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