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Comparison of the efficacy of Icon resin infiltration and Clinpro XT varnish on remineralization of white spot lesions: An in-vitro study

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Abstract

OBJECTIVE: To compare the efficacy of Icon resin infiltration and Clinpro XT varnish on remineralization of white spot lesions using a polarized light microscope (PLM).

MATERIALS & METHODS: Artificial white spot lesions were created on a sample of 40 extracted human premolar teeth by immersing in a demineralizing solution. All samples were randomly allocated to two groups of 20 each; Group A: Icon resin infiltration and Group B: Clinpro XT varnish. Teeth were sectioned along the buccolingual plane using a diamond disc. Specimens were observed under the PLM (4× magnification) at three deepest measurements and their averages were calculated to obtain the mean penetration depth. The data obtained were analyzed using SPSS software (version 22.0). Independent samples *t*-test and group statistics were used to compare the two groups. In all statistical tests, the significance level was set at 5% ($P < 0.05$).

RESULTS: Both Icon resin infiltration and Clinpro XT groups showed a statistically significant difference ($P = 0.00$) in the penetration depth. Icon resin infiltration group showed a significantly higher penetration depth (24.46 μm) compared to the Clinpro XT group (12.34 μm). Group A showed a greater mean penetration depth (17.07 \pm 4.35 μm) when compared to group B (7.68 \pm 1.81 μm).

CONCLUSION: Icon resin infiltration showed a significantly higher penetration depth and is more effective on remineralization of white spot lesions when compared to Clinpro XT varnish.

Keywords:

Clinpro XT varnish, icon resin infiltration, polarized light microscope, resin penetration depth, white spot lesions

Introduction

Every orthodontic patient wants to have a beautiful smile and aesthetics after fixed orthodontic treatment. White spot lesions (WSLs), an early sign of demineralization, is one of the most common adverse effects of orthodontic treatment, which will detract from the smile even with a well-balanced face and occlusion. Nearly 50% of patients

undergoing fixed orthodontic treatment exhibit clinically visible WSLs due to poor oral hygiene maintenance, which turns the smooth tooth surfaces into retentive sites for plaque accumulation.^[1-3] Areas that were once self-cleansing due to salivary flow and oral musculature become stagnant, plaque-collecting zones.^[4] Bacteria release lactic acid, which decreases the plaque pH adjacent to orthodontic brackets leading to demineralization or decalcification of the enamel.^[2,5,6]

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Subsurface mineral loss causes the normal translucent enamel to become opaque due to an optical phenomenon producing WSLs.^[7,8] These lesions appear in just 4 weeks around the brackets, especially in the gingival region.^[2,3,6] WSL is a major challenge during and after fixed orthodontic treatment as it leads to caries development. WSLs can be managed by various methods such as fluoride-releasing materials in the form of toothpaste, gels, varnishes, mouth rinses,^[9-13] casein derivatives such as casein phosphopeptide amorphous calcium phosphate (CPP-ACP) complexes;^[14,15] bioactive glass;^[16] laser therapy;^[17] silver nanoparticles;^[18,19] ozone therapy;^[20] bleaching, and microabrasion.^[21-23] However, these methods are very effective in preventing WSLs by remineralizing the superficial surface of the lesion and not the entire depth of the lesion.

Various methods available to assess the demineralization on the surface and sub-surface enamel are quantitative light-induced fluorescence (QLF), X-ray micro-tomography (XRMT), optical coherence tomography (OCT), confocal laser scanning microscope (CLSM), polarized light microscope (PLM), etc.^[24] However, PLM was considered as the best method that can give a high degree of differentiation between demineralized area and normal area of the tooth along with entire lesion depth measurements.

There is no golden standard for the treatment of WSLs. As WSL is a form of demineralization, remineralization is the most conservative method to be tried primarily. More recently, a minimally invasive treatment approach was introduced, where the WSL is infiltrated using a low-viscosity resin (Icon-DMG).^[25] Also, a resin-modified glass ionomer cement (Clinpro XT varnish) is introduced to the market and is supposed to be most beneficial in remineralizing WSLs; however, it is yet to be proved in orthodontic setup. Therefore, the present study was undertaken to compare the efficacy of Icon resin infiltration and Clinpro XT varnish on remineralization of WSLs using PLM.

Materials and Methods

Sample collection

A sample of 40 freshly extracted human premolar teeth was stored in 0.1% thymol solution to prevent dehydration and bacterial growth. Inclusion criteria were: 1) atraumatically extracted premolar teeth for orthodontic purposes, 2) teeth with sound noncarious premolars, and 3) teeth with no visible enamel defects.

Preparation of samples for white spot lesions

Artificial WSLs were created on the buccal surface of each tooth by immersing and storing them in a demineralizing solution (2.2 mM calcium chloride, 2.2

mM monopotassium phosphate, 0.05 mM acetic acid with pH adjusted to 4.4 and 1 M potassium hydroxide) for 96 h. All the teeth ($n = 40$) were thoroughly washed with distilled water, air dried, and then the samples were randomly allocated to two groups of 20 each. Group A: Icon Resin Infiltration (Icon DMG America, Englewood, NJ, USA) and Group B: Clinpro XT varnish (3M ESPE, Pymble, New South Wales, Australia).

Specimen preparation

Each tooth was cleaned with non-fluoridated pumice using a rubber prophylactic cup on a slow-speed handpiece and each sample was thoroughly dried for 20 s.

Group A (Icon Resin Infiltration): The buccal surface of each tooth created with WSLs was etched with 15% hydrochloric acid gel (Icon-Etch, DMG) for 2 min, rinsed with water, and dried with moisture-free air for 30 s. Ethanol 99% (Icon-Dry, DMG) was applied for 30 s and air-dried. Resin Infiltrant (Icon-Infiltrant, DMG) was applied and left for 3 min, followed by light curing for 40 s. A second coat of Icon-Infiltrant (DMG) was applied, left for 1 min, and light-cured for 40 s.

Group B (Clinpro XT varnish): The buccal surface of each tooth created with WSLs was etched with 37% phosphoric acid for 30 s, rinsed with water, and air-dried for 3 s. Then, a thin layer of Clinpro XT varnish was applied and light-cured for 20 s.

The penetration depth of the materials into the lesions was determined by immersing the specimens in 10% methylene blue dye for 24 h at 37°C in an incubator. The teeth were washed with distilled water for 60 s and allowed to dry, after which specimens are sectioned along the buccolingual plane with a diamond disc mounted on a low-speed handpiece [Figure 1]. Subsequently, specimens were observed under the

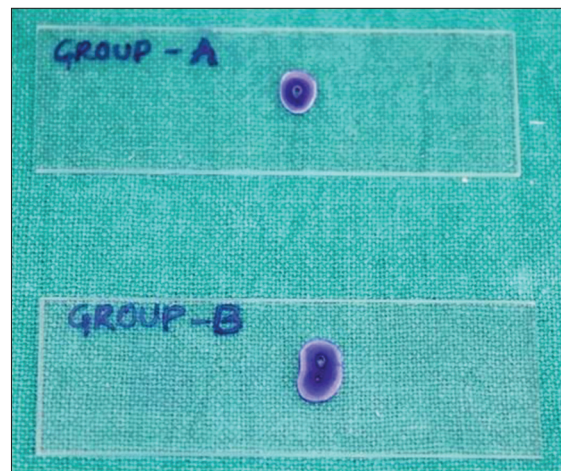


Figure 1: Sectioned Group A and Group B specimens

PLM at 4× magnification for determining the depth of penetration of the materials in micrometers (µm). PLM photomicrographs showing the penetration depth of Icon resin infiltration [Figure 2] and Clinpro XT varnish [Figure 3] suggested that the demineralized lesion appeared darkened and the infiltrated material appeared blue in color. To achieve reproducible measurements, three deepest measurements (µm) for infiltrant depth were taken for each section and their averages were calculated as the mean of maximum penetration depth.

Statistical analysis

The data obtained were analyzed using the SPSS software, version 22.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for both the groups including mean values, standard deviations, minimum, and maximum values. Independent samples *t*-test and group statistics were used to compare the two groups. In all statistical tests, the significance level was set at 5% (*P* < 0.05).

Results

The penetration depth was determined by measuring the width of remineralization at three different areas in a lesion and the average value was considered as the mean penetration depth of the materials into the lesion. In Group A sample, the mean penetration depth in the first, second, and third areas were 19.70 µm, 14.19 µm, and 17.32 µm respectively, whereas in the Group B sample, the mean penetration depth in the first, second, and third areas were 7.92 µm, 7.63 µm, and 7.49 µm, respectively [Table 1].

When comparing the two groups, with penetration depth as a dependent variable, it showed a significant difference in penetration depth between the two groups at a 5% level of significance. The Icon group showed a significantly higher penetration depth (24.46 µm) when compared to the Clinpro XT group (12.34 µm) [Table 2].

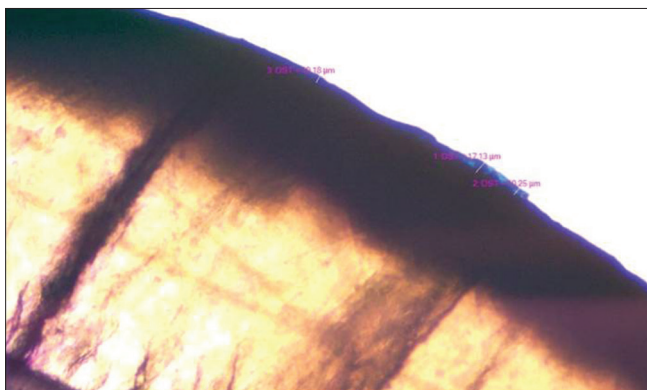


Figure 2: Polarized light microscope photomicrograph showing penetration depth of Icon resin infiltration at three different locations

An independent sample *t*-test was used to compare the mean penetration depth values between the two groups showed a statistically highly significant difference in the penetration depth. The Icon group showed a greater mean penetration depth (17.07 ± 4.35 µm) when compared to the Clinpro XT group (7.68 ± 1.81 µm), which indicated that the Icon group had greater infiltrative and remineralizing capacity when applied to demineralized enamel [Table 3].

Table 1: Mean values (µm), standard deviation, and corresponding statistics of linear measurements of penetration depths among the groups

| Descriptive Statistics | | | | | | |
|------------------------|--------------|----|---------|---------|-------|--------------------|
| Group | Area | N | Minimum | Maximum | Mean | Standard Deviation |
| Group A | Icon -1 | 20 | 13.20 | 24.45 | 19.70 | 2.86 |
| | Icon -2 | 20 | 10.18 | 22.23 | 14.19 | 4.02 |
| | Icon -3 | 20 | 10.50 | 24.46 | 17.32 | 4.30 |
| Group B | Clinpro XT-1 | 20 | 3.45 | 12.34 | 7.92 | 2.49 |
| | Clinpro XT-2 | 20 | 4.63 | 9.87 | 7.63 | 1.51 |
| | Clinpro XT-3 | 20 | 5.39 | 9.95 | 7.49 | 1.27 |

Table 2: Comparison between two study groups with penetration depth as a dependent variable

| Group Statistics | | | | | | |
|------------------|----|-------|-------|-------|-------|-------|
| GROUPS | N | Min | Max | Mean | SD | SEM |
| Icon | 20 | 10.18 | 24.46 | 17.07 | 4.35 | 0.562 |
| Clinpro XT | 20 | 3.45 | 12.34 | 7.68 | 1.815 | 0.234 |

SD: standard deviation; SEM: standard error mean.

Table 3: Independent samples *t*-test to compare mean penetration values between the groups

| Independent Samples <i>t</i> -test | | | | | | |
|------------------------------------|------------|-------|-------|----------|----------|-----------|
| Variables | Group | Mean | SD | <i>t</i> | <i>P</i> | Inference |
| Penetration Depth | Icon | 17.07 | 4.35 | 15.40 | 0.000** | HS |
| | Clinpro XT | 7.68 | 1.815 | | | |

***P*<0.001 statistically highly significant; HS: highly significant

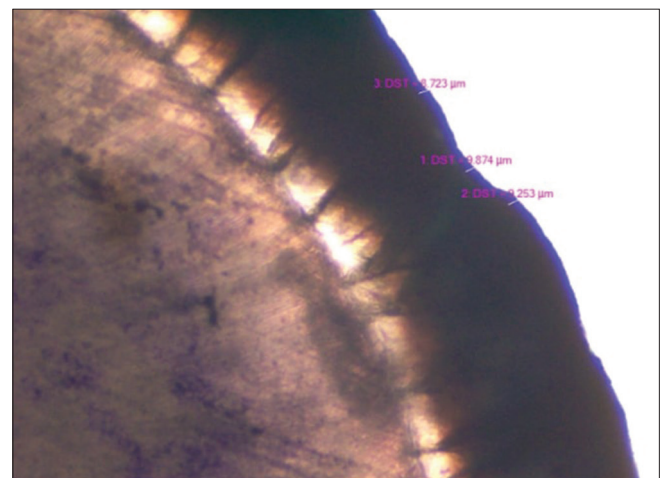


Figure 3: Polarized light microscope photomicrograph showing penetration depth of Clinpro XT varnish at three different locations

Discussion

Fixed orthodontic appliances limit the naturally occurring self-cleansing mechanisms of the oral musculature and saliva leading to increased plaque retention and subsequent WSL formation.^[26] During orthodontic treatment, those patients with poor oral hygiene maintenance, without fluoride supplementation, and with high *Streptococcus mutans* count are more susceptible to enamel demineralization and WSL formation.^[3,7,27]

Depending on a patient's risk factors, a number of suitable agents and therapies can be used to prevent WSLs in orthodontic patients. WSL treatment should start with the most conservative procedure and then progress to more invasive methods as needed.^[28] In recent years, microinvasive or minimum intervention dentistry has evolved and its aim is "maximum conservation of demineralized, non-cavitated enamel and dentin."^[29] A caries infiltrant resin (Icon) recommends the microinvasive approach by treating WSLs in one office visit without patient compliance and restores the natural appearance of the teeth. Shah *et al.*^[30] suggested that a single application of Clinpro-XT prevents enamel demineralization for up to 120 days, whereas conventional fluoride varnish prevents the same for 45 days during fixed appliance therapy. To date, there are no such *in vitro* studies that have directly or indirectly compared the effect of Icon resin infiltration and resin-modified glass ionomer Clinpro XT varnish on remineralization of artificially created WSLs.

In the present study, it was observed that the Icon resin infiltration and Clinpro XT varnish certainly have the ability to penetrate enamel affected by artificial WSL. Both the groups, i.e., Icon resin infiltration and Clinpro XT varnish had a mean penetration depth of $17.07 \pm 4.35 \mu\text{m}$ and $7.68 \pm 1.81 \mu\text{m}$, respectively. The penetration depth of Icon resin infiltration was significantly greater than the penetration depth of Clinpro XT varnish. This is in concordance with the study conducted by Arora *et al.*^[31] who concluded that the Icon resin infiltrant had the highest depth of penetration and microhardness followed by Embrace and Clinpro.

In the Icon resin infiltration group, the maximum penetration depth values obtained were $24.46 \mu\text{m}$, which is in support of a study conducted by Zankalouny *et al.*^[32] The penetration depth values obtained in our study were lower than those obtained in the study conducted by Meyer-Lueckel *et al.*^[33,34] and values obtained were higher than those in the study conducted by Subramaniam *et al.*^[35] So, the Icon resin infiltration is more effective and has a greater depth of remineralization of the lesion.

In Clinpro XT group, the maximum penetration depth value obtained was $12.34 \mu\text{m}$. Basdra *et al.*^[36] stated that the initial burst effect upon fluoride release would be more effective in preventing enamel demineralization. Contradicting this Linton *et al.*^[37] documented that rather than a high dose of fluoride. i.e., almost 225 ppm, a small dose of 50 ppm was more effective and stated that a high concentration of fluoride blocked the surface layer by preventing the penetration of calcium ions to the subsurface layer. It seems that high doses of fluoride are useful in inhibiting lesion formation and low doses are effective in remineralization and controlling the progression of lesions.^[9,11]

Caries infiltration procedure was continued to refine by examining the influence of the penetration coefficient, infiltrant composition, and application time on the penetration depth and prevention of further demineralization. Studies showed that resins with a higher penetration coefficient and longer application time allowed better penetration, but these investigations only involved a shallow carious lesion that did not require much infiltration.^[28,38,39] In our study, the Icon resin infiltration successfully penetrated the artificially created WSL and formed a homogenous resin layer compared to the Clinpro XT group. The possible reasons for this could be 1) Icon resin infiltrant composition has a high content of triethylene glycol dimethacrylate (TEGDMA), a low viscosity monomer, low molecular weight, low contact angles to the enamel, and high surface tension. These properties confer a great potential for penetration and some porous areas were observed due to high ethanol content, which also helps raise the penetration coefficient. 2) In the Icon group, acid conditioning with 15% hydrochloric acid for 2 min has led to deeper resin penetration than with 37% phosphoric acid gel as in the Clinpro XT group.^[33,40]

Conclusion

The conclusions drawn from the present study were as follows:

- Resins used in both the groups, Group A (Icon Resin Infiltration) and Group B (Clinpro XT varnish) were effective in preventing or reducing the area of demineralization.
- Group A showed significantly higher penetration depth compared to Group B.
- Icon resin infiltration group is more effective on remineralization of artificially created WSLs compared to Clinpro XT varnish group.

Abbreviations

WSLs: white spot lesions

PLM: polarized light microscope.

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Nil.

Conflicts of interest

There are no conflicts of interest

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