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Influence of resin infiltration pretreatment on the microleakage under orthodontic bracket (an *in vitro* study)

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Abstract

OBJECTIVES: In order to assess the changes in tooth orthodontic adhesive interface microleakage after applying a caries resin penetrated to the sound enamel tooth surface in different storage media.

MATERIALS AND METHODS: A total of 60 human maxillary first premolars (orthodontic extraction) were collected by random separation of the teeth into two equal groups. The control group was classified into three subgroups (n = 10) (control in deionized water, control in milk, and control in energy drink), while the experimental one (treated with ICON) was categorized into three subgroups (n = 10) (ICON in deionized water, ICON in milk, and ICON in energy drink) incubation phase lasted three weeks in total.

RESULTS: A one-way analysis of variance (ANOVA) yielded a significant difference between all experimental subgroups (ICON in deionized water, ICON in milk, and ICON in energy drink) and control subgroups (control in deionized water, control in milk, and control in energy drink). The control group in the energy drink subgroup had the highest mean microleakage value when compared to the other subgroups, whereas the resin-infiltrated group in deionized water had the lowest mean value. According to the results of the T-test, ICON pre-treatment tooth samples had significantly lower mean values of microleakage than non-ICON tooth samples.

CONCLUSIONS: The adhesive system (control group) revealed that a resin infiltrate on a sound enamel surface prior to orthodontic bracket bonding reduced bracket tooth interface microleakage in all examined samples. The ICON-infiltrated surface was discovered to provide a secondary preventive strategy against white spot lesion development by reducing microleakage under brackets.

Keywords:

Caries infiltration, enamel, ICON, microleakage, white spot lesion

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Introduction

Microleakage is a complicated situation with such a fixed orthodontic appliance therapy. It is a loss of marginal integrity that permits white opacity lesions to grow around and under the bracket, potentially resulting in a reduction of the bracket bonding strengths.[1] White spot lesions are clinical and cosmetic issues characterized by enamel demineralization, tooth discoloration, corrosion, and bond strength deterioration.[1]

Because orthodontic braces, bands, ligatures, and other orthodontic accessories are difficult to clean and increase bacterial biofilm accumulation on tooth surfaces, white spots develop around them.[2,3] White spot lesions have become more prevalent with fixed orthodontic appliances.[4,5] Oral hygiene, sex, orthodontic treatment time, wheat consumption, and diet all have an

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impact on the appearance of white spots lesions.[6,7] To avoid additional demineralization and cavitation, these lesions should be identified early.[8] restorations, crowns, and veneers, which necessitate enamel reduction beyond the demineralized area, possibly even to the dentin,[9] are among the options for treating white spot lesions. To remineralize these lesions on the surface, casein phosphopeptide amorphous calcium phosphate products such as MI Paste and MI Paste Plus, as well as fluoride dentifrice, mouthwash, gels, and varnishes, can be utilized.

Other materials and procedures, such as the use of (ICON) resin infiltration material, have recently been advocated.[10,11] Resin infiltrate is a substance with a low viscosity.[12] The primary idea of resin infiltration is to use capillary forces to enter and enclose the porosity volume of underlying defects, replenishing missing minerals, enclosing hydroxyapatite crystals, and micromechanically joining the residual enamel prisms.[13,14] The current paper was designed to evaluate the changes in tooth-orthodontic adhesive interface microleakage at the occlusal and the gingival side in three different storage media (Deionized water, energy drink, and milk drink) after applying a caries resin penetrated to the sound enamel tooth surface.

Materials and Methods

The ethical approval was acquired by the UoM.Dent/DM.L.21/22 Institutional Review Committee.

Study sample design

A total of 60 human maxillary first premolars (orthodontic purposes) were used in the study. To avoid microbial growth, teeth were maintained at room temperature in a glass container in a solution of normal saline (Panther, UK) containing 0.1 percent thymol (Sigma, Poole, Dorset, UK) that was changed weekly.[15,16] The study excluded teeth having caries, enamel abnormalities, abrasions, attrition, fractures, or any other developmental problems.[17] Buccal surfaces were scrubbed and polished for 10 seconds with a slow-speed handpiece (NSK, Japan), fluoride-free pumice, and a rubber polishing cup (China), then rinsed and dried with oil-free air steam for another 10 s.[18,19]

The teeth sample was divided equally into two main groups, with 30 teeth for each sample:

Group 1: control group samples of teeth not treated with ICON material.

Group 2: experimental group samples of teeth treated with ICON material.

Bracket bonding

In the control group, 37% phosphoric acid etching gel (Ivoclar, Vivadent, Schaan, Liechtenstein) was placed on the buccal enamel surface for 30 s, washed, and dried until the etched surface looked chalky white.[20] Stainless-steel maxillary first premolar 0.022-slot Roth prescription brackets from American Orthodontics (USA) were used. The bracket's base area was determined to be 8.686 mm^2.[21] Brackets were attached to the teeth using a thin coating of Heliosit adhesive (Ivoclar) applied to the buccal surface of the enamel in the middle third.[20] A weight of 200 grams was applied to the bracket for 10 s.[22] All unnecessary bonding excess around the bracket was cleaned. The adhesive was cured with a Viva Dent light curing unit with a light intensity greater than 500 mW/cm^2 and a wave length range of 400–500 nm.[23] The light curing device was installed on a rod to standardize the distance between the light device and the brace base to 2 mm.[24] The total curing time is 40 and 20 s for each of the mesial and distal sides of the bracket.[25] Regarding the ICON group, ICON was applied according to the manufacturer as follows:

1. Apply ICON Etch. Let it sit for 2 min
2. Water rinsing for 30 s, then dry in a water oil free air.
3. ICON Dry is used. Lie on the site for 30 s to conduct a visual assessment. The whitish, opaque lesion discoloration must diminish significantly; otherwise, repeat steps 1–3. Dry with water oil free air.
4. Switch off the operatory light. Apply Icon Infiltrate. Let it sit for at least for 3 min. Maintain the wet lesion surface with an occasional twist of the syringe.
5. Disperse with air and floss. Light cure for 40 s.
6. Replace the applicator tip. Apply ICON Infiltrate. Let it sit for 1 minute Remove excess and floss. Light cure for 40 s and polish.

Heliosit adhesive and brackets were applied similarly to the control group. To inhibit microleakage from the pulp chamber, all tooth apices were coated with sticky wax to seal the root apices. To inhibit microleakage from other places of the tooth, clear nail varnish was applied in two layers on buccal tooth surfaces, except for 1 mm around the orthodontic bracket base.[15,26] Table 1 shows the items utilized in this research.

Storage of control and experimental groups

The single mean formula [n = (Z r/D) 2] was used to calculate sample size.

n is the number of sample subjects, Z (constant) = 1.96 for 95% confidence, r is the standard deviation for other related studies = (0.213), and D (precision) = 0.2 unit. The resulting number was adjusted and the final sample size in each group = n + (n*0.2). Each group (control and experimental) was subdivided into three equal subgroups (n = 10) based on storage media as seen in Table 2:

Table 1: Material composition, Manufacturer

Material	Component	Manufacturer
ICON	- ICON etch: pyrogenic silicic acid, hydrochloric acid, surface-active substances. - ICON dry: 99% ethanol. - ICON infiltrate: TEG-DMA-based resin initiators, matrix, additives.	DMG, Hamburg, Germany.
Heliosit Adhesive	- 85% of weight for monomer matrix of urethane dimethacrylate, Bis- GMA, and decandiol dimethacrylate - 14% of weight for silica dioxide - 1% of weight for catalysts and stabilizers	Vivadent, Liechtenstein, Germany.

Table 2: Storage media, PH, Ingredients

Storage media	pH	Ingredients
Deionized water	7	Water free of cations and anions
One Tiger (Crystal Cola Co.)	6.7	Carbonated water, sugar, citric acid, sodium citrate, benzoic Acid, taurine, glucuronolactone, caffeine, inositol, caramel, acidity regulators, stabilizer, natural fruit flavors, and vitamins B2, B5, B6, and B12.
Milk (KDD Co.)	6.7	8.5% non-fat milk solids, 3% butterfat (full cream milk), Vitamins D and A, butterfat, purified water, stabilizer, and Emulsifier.

Subgroup A: Deionized water is used to keep tooth samples immersed.

Subgroup B: Tooth samples are soaked in an energy drink for 15 min, three times per day at 2-h intervals.[27] They were previously stored in deionized water.

Subgroup C: Tooth samples are dipped in milk drinks for 15 min, three times per day at 2-h intervals. They were previously stored in deionized water. The incubation phase lasted 3 weeks in total.[27]

Evaluation of microleakage

Teeth were then submerged for 24 h at room temperature in a 0.5% solution of basic fuchsine (0.5 gm of powder dissolved in 100 ml distilled water). The samples were rinsed with water; the nail varnish and the superficial pigment were cleaned with a brush.[26] At about the center of the bracket, a slow speed disk was used to segment each tooth in a buccolingual direction.[15]

A light microscope was used to assess microleakage in millimeters at enamel adhesive contacts on the occlusal and gingival sides for all sections as shown in Figure 1. The same and other investigator randomly checked half of the samples again to quantify the microleakage. There were no significant variations in microleakage ratings between the first and second tests.

The following criteria were used to score the work[21]:

Score 0: There is no dye penetration thru the adhesive-enamel contact.

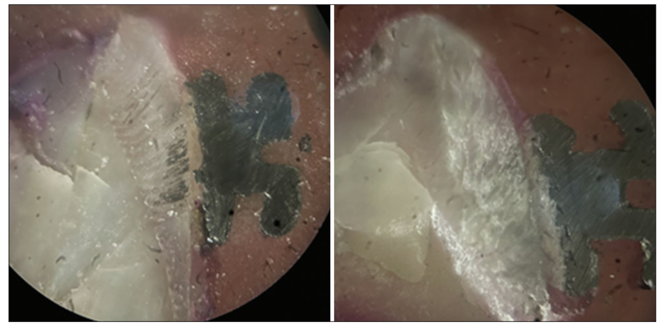

Figure 1: Under a light Microscope, microleakage at the enamel adhesive contact

Score 1: At the adhesive enamel contact, dye penetration is limited to 1 mm.

Score 2: At the adhesive enamel contact, dye infiltrates into the inner half (2 mm).

Score 3: At a depth of 3 mm, the dye penetrates the adhesive enamel contact.

Statistical analyses

Descriptive statistics were calculated for the all-teeth groups. The data showed normal distribution according to the Kolmogorov–Smirnov and the Shapiro–Wilks Normality test. A one-way analysis of variance (–ANOVA) was used to evaluate the significant differences in the microleakage at both the occlusal and gingival sides among the different storage media subgroups. Then the Tukey test was applied since the ANOVA showed significant differences.

A T-test was used to show if there is a significant difference in the microleakage mean between the ICON-treated teeth and those not treated with ICON (control). Statistical significance was judged to be $P \leq 0.05$.

Results

A significant difference was revealed using ANOVA between all ICON-treated teeth subgroups (deionized water, energy drink, and milk drink), while the comparisons in control subgroups (without ICON treatment) that were stored in different storage media were shown a significant difference, see Tables 3 and 4. The T-test findings showed that the mean value differed by a significant amount of microleakage for ICON pre-treated tooth samples over those without ICON in the same storage media as shown in Table 5. The resin-infiltrated group in deionized water had the lowest mean value of microleakage. There was the greatest microleakage value in the energy drink subgroups in the control group when compared to the other subgroups, and there was a significant difference between all subgroups at $P \leq 0.05$.

Table 3: Statistical analysis of microleakage for the control groups in different storage media

Groups	Occlusal Mean±SD	Gingival Mean±SD
Control	0.8120±0.02348 A	0.9950±0.05911 A
Control in milk	2.0220±0.12453 B	2.6350±0.12030 B
Control in energy drink	3.4920±0.06052 C	3.8970±0.07818 C
F	2740.213	2637.964
P	0.000	0.000

Significant $P<0.05$. Tukey group different letter mean difference is significant

Table 4: Statistical analysis of microleakage for experimental groups in different storage media

Groups	Occlusal Mean±SD	Gingival Mean±SD
ICON	0.3250±0.01080 A	0.4410±0.01197 A
ICON in Milk	0.6120±0.01751 B	0.9460±0.04742 B
ICON in Energy Drink	1.6170±0.07903 C	1.9630±0.09615 C
F value	2070.553	1549.178
P value	0.000	0.000

Significant $P<0.05$. Tukey group different letter mean difference is significant

Table 5: Statistical analysis of microleakage between the control and experimental groups that stored in the same storage media

	Pair	*t*	Sig.
Pair (1)	Control Occlusal – Icon Occlusal	65.273	0.000
Pair (2)	Control Gingival – Icon Gingival	32.569	0.000
Pair (3)	Control Milk Occlusal – Icon Milk Occlusal	36.986	0.000
Pair (4)	Control Milk Gingival – Icon Milk Gingival	50.002	0.000
Pair (5)	Control Energy Drink Occlusal – Icon Energy Drink Occlusal	50.342	0.000
Pair (6)	Control Energy Drink Gingival – Icon Energy Drink Gingival	81.054	0.000

Significant $P<0.05$

Discussion

There was a significant difference between all subgroups (deionized water, energy drink, and milk) in both the control and ICON pre-treated groups.

The impact contrast of the microleakage test between control and ICON pre-treated groups was shown in Tables 3 and 4, where data point toward a highly significant difference at $P \leq 0.05$ between all groups, and assessing the microleakage test with and without implementation of ICON, which was used as a preventative measure procedure on induced white spot lesions at the enamel surface,[28,29] Table 5 shows a marked difference in microleakage between groups.

Since the energy drinks include acids, the energy drinks subgroup in the control group revealed the highest microleakage percentage at the adhesive enamel interface, which was consistent with the findings of Pulgaonkar and Chitra, (2021)[30,31] study in explaining a detrimental influence on the brackets. Enamel demineralization brings about enamel erosion and adhesive material loss, as well as an increase in microleakage behind the brackets; this might also be linked to the presence of high doses of refined carbs, which promote greater levels of acid. Furthermore, citric acid and citrate are capable of binding to calcium in the teeth, keeping the pH low for extended periods of time and promoting microleakage, as described by Oncag *et al*., 2005.[32]

For the all-tested subgroups, gingival sides exhibited considerably greater microleakage than occlusal sides. This is consistent with the findings of Arhun *et al*., 2006[33] who related variation to relative surface curvature, which might lead to higher adhesive on the gingival side. Microleakage can occur as a result of permeation, which is produced by a discrepancy in the thermal expansion coefficients of brackets, enamel, and adhesive. This is something that both Salman and Al-Ani, (2021) agree with.[15]

After the control in energy drink, the control in milk group had a significant high microleakage. Because milk lipids are insoluble in water, they would attach to the surface of the bonded teeth. Fat accumulation weakens the resin and intensifies the microleakage. This is supported by Anicic *et al*. (2020).[34]

ICON's low viscosity allows it to efficiently penetrate the tooth enamel. Microleakage in the ICON groups (ICON, ICON in milk, and ICON in energy drink) was lesser than in the other control subgroups, according to statistical analysis, which agrees with Li *et al*. (2021).[35] The findings are related to the capacity of resin infiltration to successfully seal porous structures in the enamel and boost the ability of sound enamel surfaces to withstand acid erosion and demineralization, making it harder for external acids to access holes in the enamel. As a result, resin penetration may aid in preventing acid erosion and demineralization of dental enamel. Arnold *et al*. (2016)[36] also found that adding resin infiltrate to enamel caries can supply and preserve enamel.

Conclusion

It was determined that the ICON-infiltrated surface might be used as a secondary preventative strategy against white spot lesion development in orthodontic patients by reducing microleakage under brackets. The acidic solution and fatty beverages increased microleakage under the orthodontic braces.

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Ethical approval

The ethical approval was acquired by the UOM. Dent.L.21/22 Institutional Review Committee.

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Conflicts of interest

There are no conflicts of interest.

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