Evaluation of Simulated Toothbrushing with different Dentifrices on Enamel Resin Infiltrated Teeth Surface Roughness and Gloss

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Abstract

To evaluate the effect of simulated toothbrushing with different dentifrices on surface roughness and gloss of resin-infiltrated enamel. Thirty human premolars were prepared to have white lesion on half of buccal enamel surface then received resin infiltration. The specimens were submitted to toothbrushing simulation with different relative dentin abrasion dentifrices. Surface roughness and gloss were measured before white lesion preparation and after simulated teeth brushing. The obtained data statistically analyzed using IBM SPSS Statistics 20 Software with one-way ANOVA followed by Tukey's multiple comparison tests ($P \leq 0.05$). There was a significant increase in surface roughness and gloss reduction for Icon resin infiltered enamel surface simulated teeth brushing with all dentifrices. Conclusions: Toothbrushing with different relative dentin abrasion (RAD) dentifrices increased the roughness and diminished the gloss of the resin infiltrated enamel surface.

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Introduction

White spot lesions (WSLs) are the first signs of incipient enamel caries, and they are characterized by a loss of minerals under an intact surface layer and a whitish appearance[1-5]. WSLs are considered a common complication of fixed orthodontic treatments which could affect the esthetic result of any such treatment[6-8].

In many cases, because of the abrasive effect of tooth brushing, WSLs may remineralize and return to a visually acceptable appearance within one year after debonding. However, in other cases, WSLs may remain at an esthetically located unacceptable[9,10]. Either invasive or noninvasive procedures are employed to prevent WSLs and carious development. Researchers preferred a non-invasive strategy for early lesions of enamel, such as remineralization[11].

Popular treatment selected for WSLs includes improving remineralization by way of CPP-ACP (Casein Phosphopeptide-Amorphous Products containing calcium phosphate) or fluoride releasing products, restorative procedures, microabrasion, or using a laser[2]. Often these techniques are effective for shallow WSLs that demand a lot of clinical effort[3]. Long-term effects of fluoride applications are likely to lead to expansion of drug resistant bacteria. Hence the type of treatment for infiltration introduced in the early 1970s was an attempt to reduce the risks associated with non-invasive techniques[12]. Infiltration is a promising therapeutic strategy because it uses both preventive and restorative steps in the treatment of demineralized initial carious lesions[13]. After removal of the hypermineralized surface layer, low-viscosity resin (an infiltrant) penetration into the lesion depth is powered by capillary forces[3,14]. So that, the progression of the lesion is slowed down and even stopped by occluding the porosities which increase the diffusion of acids. This not only reduces the microporosities but also provides some mechanical support for the treated tissue[13,14].

Resin infiltration of WSLs masks the enamel whitish appearance as a resin refractive index (RI=1.42) is similar to that of healthy teeth enhancing treated lesions with a natural appearance[8].

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Many studies indicated that the color of the ICON infiltration was not altered after 4 years of exposure to the oral environment [15].

The smooth surface of any restoration maintains both the best esthetics appearance and low plaque accumulation [16]. More rough texture of the surface will reduce the gloss and increase the material surface discoloration, both of which affect the surface restoration esthetic quality [17]. Surface roughness refers to the finer surface texture irregularities that are typically the result of the manufacturing process or the properties of material [18]. A clinical analysis found a roughness mean 0.2 µm is critical threshold value for the retention of bacteria [19].

American Dental Association recommends brushing your teeth twice a day with fluoride toothpaste for two minutes each time. When you brush your teeth, you help remove food and plaque: a sticky white film that forms on your teeth and contains bacteria [20]. Commercially available dentifrices have abrasive systems to achieve teeth cleaning with minimal side effects. Abrasiveness measurements are presented by relative dentin abrasion (RDA) [21]. Many RDA values present with different dentifrices formulae. American Dental Association recommended the limit of RDA values 30-250 (Consumer Reports reviewed toothpastes,1998).Determining the performance of the restorations as a result of ,toothbrushing with different dentifrices, abrasion is clinically important, as this phenomenon increases surface roughness and decreases gloss, thus affecting the restoration esthetic quality .A variety of commercially available dentifrices which have some abrasive properties.

The purpose of this study was to evaluate the effect of three different commercially available dentifrices on the surface roughness and gloss of Icon resin infiltrated enamel surface after simulated toothbrushing.

The null hypotheses were no changes in resin infiltered human enamel surface roughness and gloss due to simulated toothbrushing with the tested dentifrices.

Materials and methods

Specimen preparation

Thirty extracted, for periodontal problems, premolars and stored in a 0.2% thymol solution at 3°C for one week.

Selected teeth were checked at 10x magnification under a stereomicroscope (SZ40, Olympus, Japan) to detect any defects that could interfere with the results obtained.

The roots were separated from the crowns using a cooled low speed diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA).The specimens were randomly divided into three groups each group of ten specimens, according to tooth paste used with simulated tooth brushing cleaning method, analyzed and kept in artificial saliva at 37°C before taking all measurements.

Formation of white spot lesions

To detect the artificial WSLs formation , right vertical half of the labial enamel surface of each specimen was covered with adhesive tape and the left vertical half of the buccal enamel surface coated with acid-resistant nail varnish (Danipro ,USA) then removal of the adhesive tape of tested right vertical half of the labial enamel.

Specimens were stored for 28 days at 37.8°c in five liters of demineralizing solution (pH 4.95) formed of 50 mM acetic acid, 50 mM KOH, 3 mM, 3 mM CH3COOH, 3 mM KH2PO4, CaCl212H2O, 10 mM methylhydroxy-diphosphonate. The pH level was recorded daily and could be adjusted with either potassium hydroxide solution (10 M) or hydrochloric acid (10%) [22].

ICON infiltration application

ICON (DMG, Germany) resin infiltration was applied to according to the manufacturer's instructions on the triggered WSLs:

1st step application of ICON-Etch (15 % Hydrochloric acid gel) for 2 minutes then rinsing with water spray for 30 s then gentle air drying.

2nd step ICON-Dry (Ethanol) applied for 30 s then gentle air-drying.

3rd step ICON-Infiltrant applied and left for 3 min. Excess resin was removed away with a cotton roll then specimens light cured for 40 s (Hilux Ledmax 5, Benlio_glu Dental Inc, Turkey). The resin infiltrant reapplied for 1 minute then the specimen was light cured for another 40 s.

Specimens tested enamel surfaces polished using resin composite polishing flexible discs (Sof-Lex, 3M ESPE, USA) for 20 seconds to remove any excess resin. The specimens stored in distilled water at room temperature during the

intervals between the treatment phases. The specimens were randomly divided into three groups according to the experimental protocols (n = 10). Specimens were evaluated for surface roughness and gloss.

Baseline measurements

Surface roughness

Specimens surface roughness evaluated using a surface roughness profilmeter (TR 200, TIME Group, Pittsburgh, PA, USA). Five traces of roughness, using a tracing length of 2 mm and a cutoff value of 0.25mm were recorded for each specimen, the mean of five tracing for every specimen was calculated and taken as the surface roughness value of the specimen (Ra, µm).

Gloss

Gloss, measured in GU, was measured using a small area glossmeter (Novo-Curve, Rhopoint Instrumentation, East Sussex, UK), with a measurement of square area of 2mm x 2 mm and a geometry of 60°.

A jig has been designed to place the specimen at the same place each time over the aperture and Four measurements were performed with the specimen 90° revolving around its core. The mean of the four measurements has been calculated.

Teeth embedded in self-cure acrylic resin held by a plastic ring mold (diameter 2 cm, thickness 0.5 cm) so that the teeth labial surface aligned parallel with the base of the mold for easy holding to simulated tooth brushing machine.

Toothbrushing simulation and properties reevaluation

After the baseline measurements, The specimens were removed and dried with tissue paper and submitted to a simulated tooth brushing procedures in a brushing machine (*MEV2*, *Odeme Biotechnology*, *Joaçaba*, *SC*, *Brazil*) using 280 strokes/100 g of tested dentifrices : Colgate 2-in-1 Fresh Mint or Crest Pro Health Enamel Shield or Arm & Hammer Dental Care PM Fresh Mint (table 1).

This cycle was repeated weekly over a period 10 weeks. After simulated toothbrush abrasion the specimens were re-evaluated for surface roughness and gloss.

Dentifrice	RDA	Manufacture
Colgate 2-in-1 Fresh Mint	70	Colgate-Palmolive Company New York, USA
Crest Pro Health Enamel Shield	145	Procter and Gamble Company, Ohio, USA
Arm & Hammer Dental Care PM Fresh Mint	168	Church & Dwight Company, New Jersey, USA

Table 1. Tested Dentifrices.

Statistical analysis

The statistical analysis was performed using IBM SPSS Statistics 20 Software.

A three-way ANOVA was initially performed for the surface roughness data and gloss (Icon resin infiltration, dentifrice and time (before and after brushing) as the three independent variables. The data for each dentifrice was analyzed by individual two-way ANOVA followed by Tukey's multiple comparison tests ($P \leq 0.05$) to evaluate the effects of dentifrice and brushing time on surface roughness and gloss.

Results

Surface roughness results

There was a significant increase in surface roughness for Icon resin infiltered enamel surface simulated brushing with all dentifrices (table 2).

Dentifrice	Time	Surface roughness	SD
Colgate 2-in-1 Fresh Mint	Before	0. 32 [a]	0.03
	After	0. 37 [b]	0.06
Crest Pro Health Enamel Shield	Before	0. 31 [a]	0.03
	After	0. 39 [c]	0.08
Arm & Hammer Dental Care PM Fresh Mint	Before	0.31 [a]	0.03
	After	0.43 [c]	0.09

Table 2. Results compare the surface roughness of Icon resin infiltrated enamel surface before and after brushing with tested dentifrices. Values with the different superscript are significantly different.

Dentifrice	Time	Gloss Unit	SD	Gloss reduction percent
Colgate 2-in-1 Fresh Mint	Before	65 [a]	7.5	15%
	After	56 [b]	11.4	
Crest Pro Health Enamel Shield	Before	65 [a]	9.8	43%
	After	33 [b]	7	
Arm & Hammer Dental Care PM Fresh Mint	Before	65 [a]	8.5	49%
	After	31 [b]	10.5	

Table 3. Gloss results before and after brushing with different dentifrices, and percentage of gloss reduction (%) after toothbrushing.

Gloss results

There was a significant reduction in gloss of Icon resin infiltrated enamel after brushing with all tested dentifrices table (3).

Scanning electron microscope results

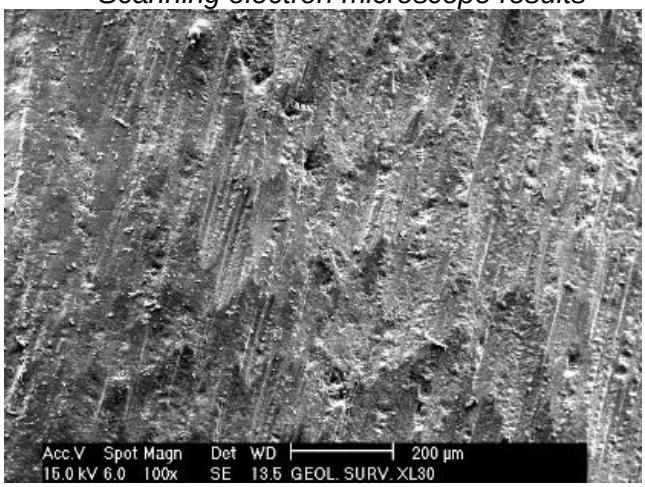

Figure 1. Demineralized enamel surface view showing loss of integrity and aprismatic enamel surface.

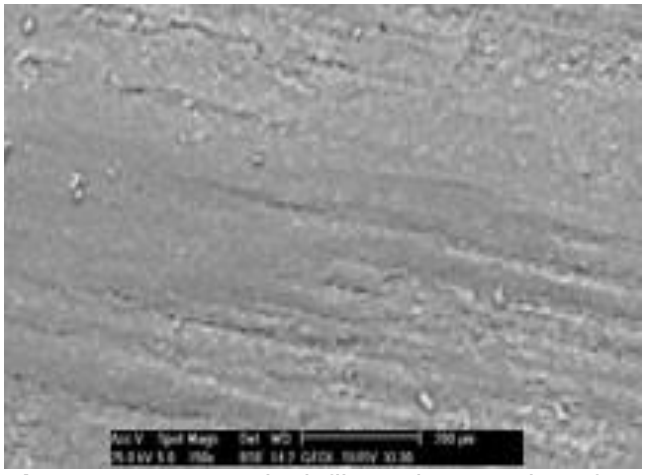

Figure 2. Icon resin infiltrated enamel surface before brushing showing surface integrity re-established.

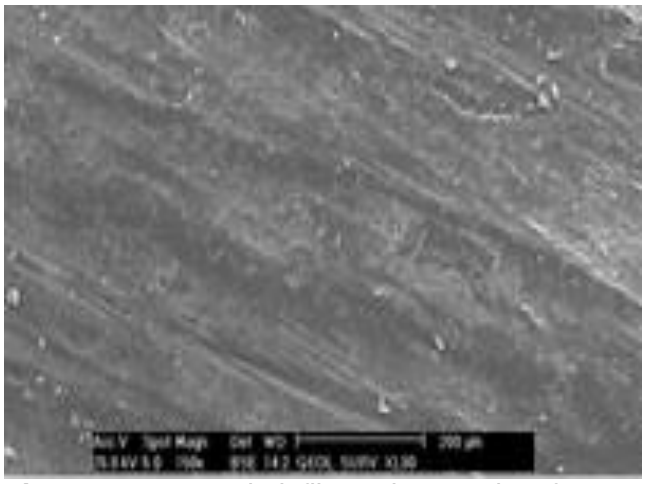

Figure 3. Icon resin infiltrated enamel surface after simulated brushing showing slight increase in surface irregularities.

Discussion

The growing importance of conservatism and dental aesthetics in professional peoples and social lives needs restorative materials capable of replacing and mimicking the characteristics of dental tissues damaged by caries or traumas .This means that the restorations made up with such materials should mimic aesthetic characteristics, such as surface smoothness, color, translucency and gloss of enamel and dentin, in addition to having improved mechanical properties, and, mainly, preserve stability over time.

In the present study, the way in which simulated toothbrushing with different dentifrices would affect roughness, and its influence on color gloss of human resin infiltrated enamel over a period of ten weeks.

in the present study design, each specimen was brushed individually using 280 strokes per week. This number was based on an estimation that in every 2 min daily toothbrushing, every tooth is brushed for 10 s. Considering that a person brushes their teeth twice a day, this means that on average each tooth is subjected to 2 strokes per sec ,40 strokes per day, 280 strokes in a week.

Specimens tested resin infiltrated enamel surfaces polished using resin composite polishing flexible discs (Sof-Lex, 3M ESPE, USA) for 20 seconds to remove any excess resin. This step to ensure that all specimens had similar initial roughness and thus the final results reflected the actual behavior of resin infiltration material[23].

There are two aspects one can see the clinical significance of roughness. First, this property is closely linked to colonization of bacteria on surfaces located in the oral environment. In addition, an increased surface roughness (difference between peaks and valleys) reduces the possibility of the oral biofilm dislodging[24].

The second aspect, an increase in the surface roughness can interfere with many changes in color, translucency and gloss of the restored dental surfaces[25,26]. The enamel resin infiltrated surfaces presented a significant increase in roughness after ten weeks of simulated brushing with various tested dentifrices. (Table 2)

The SEM results showed that resin infiltration application to the demineralized enamel surface had sealed the enamel porosities and the resulting surface appeared smooth than demineralized enamel surface, while after brushing with the highest RDA tested dentifrice, the surface roughness is increased.

Roughness occurred may be attributed to wear of the resin layer covering the enamel surface leaving the infiltrated enamel lesion exposed. Although the resin infiltrate is capable of occupying the space within the lesion's body, the resin infiltrated enamel surface is characterized by the presence of holes and column gaps between the cured resin material that indicate poorly infiltrated mineral phase.

The presence of a thick coating layer of resin above the lesion was also an obvious feature for the infiltrated enamel [(27)]. In other studies, for the infiltrated lesions, irregular surface profiles were common and this was due to peeling and blistering of the resin-covering layer. They also observed macroscopic voids, which may result from natural enamel cracks in human un treated enamel[14,28-29].

However, the process of artificial demineralization using the acetic acid may preferably demineralize along those pre-cracks of enamel, thereby creating greater voids. Large voids of the natural lesions are less prominent. However, once they are present it is difficult for a highly shrinking resin infiltrate with low viscosity to fill and bridge those large gaps[30].

This study results showed that low RDA dentifrices are less abrasive than medium or moderate RDA dentifrices. These findings presented as less surface roughness and gloss reduction of resin infiltrated enamel surface after simulated toothbrushing.

Gloss is a visual characteristic that develops from the specular and selective reflection of light incidents on a material surface and is influenced by the material refractive index and the reflected light incidence angle[31-32].

Many previous studies have shown a strong association between roughness and gloss[23,33-34]. Other studies mentioned that increasing the roughness would increase the random reflection of light and thus reduce the gloss[8,35].

Our results showed that when comparing the data from table 2 and 3 it can be concluded that rational increasing in surface roughness after toothbrushing tends to lead to decrease in surface gloss.

Conclusions

It can be concluded, within the limitations of this study Dentifrices with a lower RDA number could promote less increase in surface roughness with less gloss reduction and for resin infiltrated enamel surfaces.

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Declaration of Interest

The author report no conflict of interest.

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