

## EFFECT OF TOOTHBRUSH ABRASION ON SURFACE ROUGHNESS OF DEMINERALIZED ENAMEL TREATED WITH RESIN INFILTRATION

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### ABSTRACT

This study was conducted to evaluate the effect of the toothbrush abrasion on surface roughness of the demineralized enamel treated with resin infiltration.

**Materials and methods:** A total number of 12 extracted caries-free human permanent premolars were used in this study. Surface roughness assessment of specimens (sound enamel) was performed using Environmental Scanning Electron Microscope ( $R_1$ ). Specimens were subjected to a demineralization protocol until a white spot lesion (WSL) was developed (chalky white lesion) (surface roughness  $R_2$ ). Resin infiltrant was applied on the WSL ( $R_3$ ), followed by tooth brush abrasion ( $R_4$ ). Surface roughness assessment of specimens (R) was performed qualitatively and quantitatively using Environmental Scanning Electron Microscope for each of the four stages of the study.

**Results:** One-way ANOVA showed statistical significant difference between the tested groups ( $P= 0.001$ ). The post-hoc test revealed that sound enamel has significantly the lowest surface roughness than all other tested groups ( $P= 0.001$ ). Moreover, demineralized enamel and toothbrush abraded resin infiltrated enamel had significantly lower surface roughness than that of resin infiltrated enamel ( $P= 0.001$ ). No significant differences were revealed between demineralized enamel and toothbrush abraded resin infiltrated enamel ( $P= 0.309$ ).

**Conclusions:** Within the limitations of the study, it can be concluded that: 1- Surface roughness of enamel with artificial carious lesion treated with resin infiltration was higher than that of sound enamel. 2- Tooth brushing have the potential to lower the surface roughness of artificial carious lesion treated with resin infiltration.

### INTRODUCTION

Non invasive treatment protocols are of the main focus points of conservative dentistry nowadays. Several attempts have been made to stop the progress of an incipient enamel lesion, increasing

tissue preservation and preventing cavitation of the dental structure. Assessment of the therapeutic effect provided by these attempts has been made under various settings. Microabrasion<sup>(1-3)</sup> and resin infiltration<sup>(4-8)</sup> methods were reported to produce

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satisfactory results in shorter time intervals, compared with remineralization using fluoride or amorphous calcium phosphate derivatives.

Resinous infiltration, and occlusion of early lesion's micro-spaces & micro-porosities with a low viscosity resin obstructing the inward diffusion pathway for acids<sup>(9-13)</sup> and outward flow of dissolved minerals at an early caries development stage was one of the promising lines of treatment that was developed in the past ten years and now introduced in markets.<sup>(14-23)</sup>

Today resin infiltration is considered as a well known treatment regimen related to minimal intervention dentistry<sup>(24)</sup>. It was noticed that producing a barrier on top of the lesion was not as important as fully occupying the inner space with resin to prevent progression<sup>(25)</sup>. Low viscosity resinous materials provided attainable depth of penetration and ability of arresting the progression of caries, several surface treatments and time of application have been proposed by several studies<sup>(9,11)</sup>.

Compared to artificial caries-like lesions, natural lesions have rather more complex micro-structural patterns. Yet artificial caries-like lesions have the advantage that they can be produced under standardized reproducible conditions<sup>(26)</sup>.

Surface roughness of the resin infiltrated incipient enamel lesion is one of the major determinant of long term prognosis of the line of treatment, as the produced roughness may facilitate plaque build-up, encouraging demineralization and development of secondary carious lesion. Therefore, the surface roughness resulting from toothbrush abrasion of resin infiltration treatment is important for evaluation, of the long term prognosis of the line of treatment.

Furthermore, no information is available on how resistant these treated surfaces will be against toothbrush abrasion, a challenge that tooth surface faces on regular bases. Therefore, the aims of this study were to evaluate the effect of toothbrush abrasion on surface roughness of demineralized enamel treated with resin infiltration.

## MATERIALS AND METHODS

A total number of 12 extracted caries-free human permanent premolars were used in this study. Teeth were washed with water, scaled with periodontal scaler to remove any blood, attached periodontal tissues, plaque and calculus. Teeth were then stored in 0.1% Thymol solution at room temperature till the time of their use. The buccal surface of each tooth was covered by an acid-resistant nail varnish (Maybelline Ultra Lasting; Gemey-Maybelline, Paris, France) leaving only a window of 2mm×2mm in the middle/middle of the buccal surface.<sup>(27)</sup>

**Baseline:** Surface roughness was measured for the sound enamel surface

**Demineralization:** The initial erosion lesion was obtained in vitro by immersing the specimens in citric acid solution (0.30 mol/L, pH 2) for 60 min, at room temperature (25 C), until a white spot lesion (chalky white lesion) was developed. After that the teeth were rinsed using air water spray for 1 minute to ensure washing all remnants.

Surface roughness was measured for the demineralized enamel surface

**Resin infiltration by Icon system:** Application of Icon [Tab.(1)], as recommended by manufacturer. Surface roughness was measured for the resin infiltrated enamel surface

**Toothbrush abrasion:** The samples were subjected to toothbrush abrasion using a toothbrushing machine with horizontal movements of the toothbrush under a weight of 0.2 kg and a traveled course of 3.8 cm. The rotation was of 240 cycles/min, the total time of tooth brushing was of 100 min, so total cycles were 24000 cycles. Toothbrush head was replaced with every new sample, while a slurry mixture was applied every 5 minutes of the testing time.<sup>(28)</sup>

Surface roughness was measured for the treated enamel surface after toothbrush abrasion.

TABLE (1) Material used, manufacture, composition and steps of application

Material	Manufacture	Composition	Application
ICON	DMG (Hamburg, Germany)	Icon-Etch: hydrochloric acid Salicylic pyrogenic acid. Surface- active substances.	Applied for 120 s.
		Icon-Dry: 99% ethanol.	Applied for 30 s with air drying.
		Icon-Infiltrant: TEGDMA-based resin, initiators and additives.	Applied for 180 s, reapplied for 60 s, cured for 40 s

### Surface roughness measurements and Statistical Analysis:

Surface roughness assessment of specimens was performed qualitatively and quantitatively using Environmental Scanning Electron Microscope. Base line ( $R_1$ ), demineralized ( $R_2$ ), infiltrated ( $R_3$ ) and toothbrush abraded ( $R_4$ ) stages of the enamel surface were recorded and tabulated. Data were subjected to the statistical analysis.

### RESULTS

ESEM three dimensional image of the tested enamel surfaces are represented in the Fig (1) where (a) showing minimal surface roughness of sound enamel surface, (b) showing increased surface roughness enamel surface as a result of demineralization, (c) resin infiltrated enamel and (d) toothbrush abraded resin infiltrated enamel.

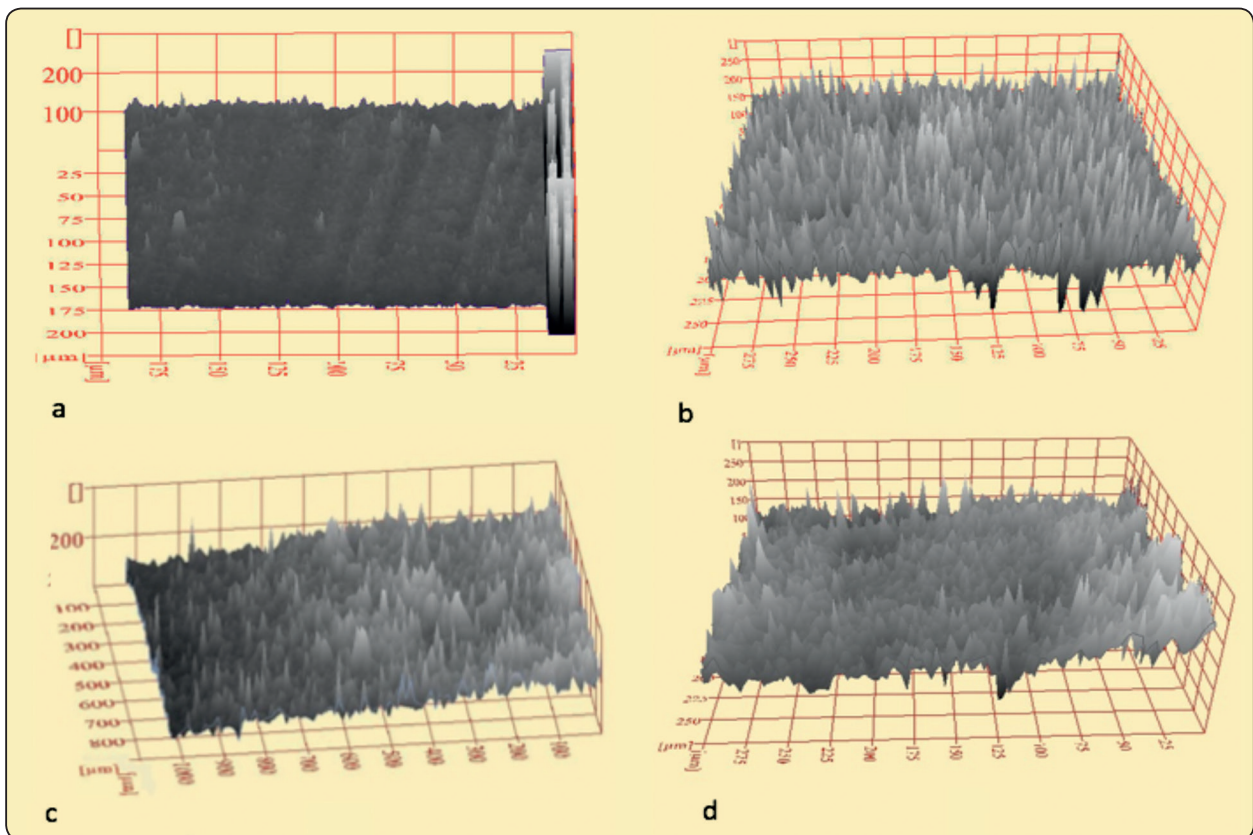


Fig. (1) Three dimensional image of the tested enamel surfaces. (a) sound enamel surface ( $R_1$ ), (b) demineralized enamel surface ( $R_2$ ), (c) resin infiltrated enamel ( $R_3$ ) and (d) toothbrush abraded resin infiltrated enamel ( $R_4$ ).

The Mean enamel surface roughness and standard deviation of values are described in Table (2) & Fig (2). One-way ANOVA showed statistical significant difference ( $P= 0.001$ ). The post-hoc test revealed that sound enamel has significantly the lowest surface roughness than all other tested groups ( $P= 0.001$ ). Moreover, demineralized enamel and

toothbrush abraded resin infiltrated enamel had significantly lower surface roughness than that of resin infiltrated enamel ( $P= 0.001$ ). No significant differences were revealed between demineralized enamel and toothbrush abraded resin infiltrated enamel ( $P= 0.309$ ).

TABLE (2) Mean and standard deviation of enamel surface roughness

Tested Enamel surface	Mean In $\mu\text{m}$	Standard Deviation
Sound Enamel ( $R_1$ )	135.3033 <sup>(a)</sup>	9.30577
Demineralized Enamel ( $R_2$ )	185.6667 <sup>(b)</sup>	6.28611
Resin Infiltrated Enamel ( $R_3$ )	198.9433 <sup>(c)</sup>	6.17029
Toothbrush abraded Resin Infiltrated Enamel ( $R_4$ )	182.6667 <sup>(b)</sup>	6.28611

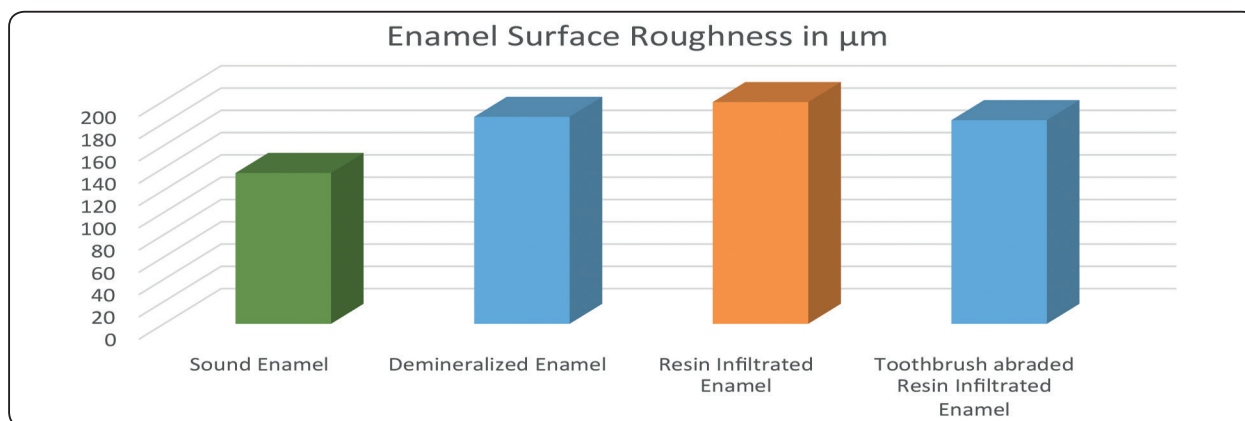


Fig. (2) Mean enamel surface roughness in micrometers

## DISCUSSION

Surface roughness of enamel incipient lesions plays a significant role in increasing the rate of plaque accumulation, maturation and retention, which has a drastic effect on caries and periodontal inflammation risk, and could also contribute to extrinsic staining of teeth. <sup>(29)</sup>

Homogenously infiltrating the demineralized defect using a low viscosity resinous material would be beneficial in breaking the caries cycle.

But leaving a resinous layer over the lesion could deprive the procedure from its main goal as it will add to the surface roughness of the substrate, offering retentive sites for plaque and hence increasing caries risk. <sup>(30,31)</sup>

The ESEM results [Fig. (1)] revealed that the infiltrate applied to the demineralized enamel surface had appeared to be projecting from the surface. Those observations might explain the recorded surface roughness values of enamel when

treated with resin infiltrate. However, surface roughness has dropped significantly when exposed to toothbrush abrasion which may be attributed to the wear of the resinous layer covering the enamel surface leaving the infiltrated lesion exposed.

Although the resin infiltrate is able to occupy the space within the body of the lesion, the resin infiltrated enamel surface is characterized by the presence of holes and column gaps amongst cured resin material signifying poorly infiltrated mineral phase. Also clearly obvious feature for the infiltrated enamel was the presence of a thick coating layer of resin above the lesion.<sup>(32)</sup> Irregular surface profiles were common in other studies<sup>(20,23)</sup> for the infiltrated lesions and they owed this to peeling and blistering of the resin-covering layer. They also detected Macroscopic voids, that might arise from natural enamel cracks that are present in human enamel. However, the artificial demineralization process using the citric acid might preferably demineralize along those enamel pre-cracks, thereby creating larger voids. Large voids are less prominent in natural lesions. However, once they are present it is difficult for a low-viscosity (and therefore highly shrinking) resin infiltrate to fill and bridge those large gaps.

The pre-treatment in citric acid solution could have influenced our findings, increasing the enamel dissolution and, consequently, changing its surface roughness. Belli *et al.*<sup>(25)</sup>(2011) have also observed that bovine enamel has macroscopic-sized voids that can accelerate the caries process, thereby acting as an obstacle against proper resin infiltration. Therefore, the enamel can present demineralized zones unfilled by the infiltrating resin, increasing surface roughness

The surface changes after brushing may be attributed to the loss of the low wear resistant resin layer that remains on the top of the enamel surface<sup>(33)</sup>, such loss may have been aggravated by the presence of oxygen inhibited polymerization surface layer of resin infiltrate due to the inability of TEGDMA to hinder air diffusion as efficiently

as other high viscosity monomers, that drastically affects surface properties of resin infiltrate.<sup>(34)</sup>

After resin infiltration a mild significance was detected in surface roughness which is in accordance with the results of Yuan *et al.*<sup>(35)</sup> (2013), who recommended the polishing of the infiltrated surface. Which also can explain the performance of the infiltrated surface after tooth brushing.

## CONCLUSIONS

Within the limitations of the study, it can be concluded that:

- 1- Surface roughness of enamel with artificial carious lesion treated with resin infiltration was higher than that of sound enamel.
- 2- Tooth brushing have the potential to lower the surface roughness of artificial carious lesion treated with resin infiltration.

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