**International Journal of Current Advanced Research**
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 11; Issue 05 (A); May 2022; Page No.860-863
DOI: http://dx.doi.org/10.24327/ijcar.2022.863.0196

**Research Article**

# EVALUATION OF SURFACE ROUGHNESS OF INCIPIENT CARIOUS LESION FOLLOWING RESIN INFILTRATION AND MICROABRASION - AN IN-VITRO STUDY

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**A R T I C L E I N F O**

***Article History:***

Received 12th January, 2022
Received in revised form 23rd March, 2022
Accepted 7th April, 2022
Published online 28th May, 2022

***Keywords:***

Dental caries; enamel microabrasion; roughness; tooth demineralization; resin infiltration.

**A B S T R A C T**

**Context:** In most recent years the treatment of dental caries has reformed from large invasive techniques to non-invasive or minimally invasive preventive techniques.

**Aim:** The aim of the study is to evaluate the effects of resin infiltration and microabrasion on incipient carious lesions by surface roughness and resistance to further acid attack of treated lesions.

**Materials and method:** Fifty five artificially-induced incipient lesions were randomly divided into five groups (n $^{1/5}$ 11): resin infiltration with an adhesive resin (Tetric N Bond Universal, IvoclarVivadent, Schaan, Liechtenstein), resin infiltration with a resin infiltrant (Icon, DMG, Hamburg, Germany), microabrasion without polishing (Opalustre, Ultradent, South Jordan, UT, USA), microabrasion with polishing (Opalustre, Ultradent, South Jordan, UT, USA), and distilled water (control group). All specimens were exposed to demineralization for another 48 hours. Surface roughness evaluation was done following initial demineralization, treatment and further demineralization. Data were analysed by One-way ANOVA, Continuous variables were described in terms of mean and standard deviation and for the multiple comparison, Tukey's HSD test was used .

**Statistical Analysis used:** All the data were collected and analysed using SPSS version 23.0 . The level of significance was set at $p < 0.05$. One-way ANOVA was used for comparison of 5 groups (p value <0.05 is considered significant).Continuous variables were described in terms of mean and standard deviation. For the multiple comparison, Tukey's HSD test was used (p value <0.05 is considered significant).

**Results:** Resin infiltration demonstrated lower roughness values than those of microabrasion, and the values did not reach the values of sound enamel. Further demineralization for 48 hours increased the roughness of infiltrated and microabraded enamel surfaces. Polishing did not influence the roughness of microabraded enamel surfaces.

**Conclusion:** Within the limitations of this study, the icon infiltration appeared to provide reduced roughness, although not equal to sound enamel. Further research is needed to elucidate their clinical relevance.



## INTRODUCTION

Dental decay is a microbial, infectious and multifactorial disease. It remains a vastly dominant pathology globally.[1] The first treatment of choice for dental caries was restoring the tooth structure with dental restorations. In most recent years the treatment has reformed from large invasive techniques to non-invasive or minimally invasive preventive techniques.[2] During the development of subsurface caries lesions, enamel will be dissolved out of mineral, resulting in increased porosities which clinically appear as the so-called 'white-spot' lesions. These days, these lesions are generally treated by increasing remineralization, e.g., by enlightening the individual's oral hygiene or fluoridation. However, in noncompliant individuals with cavitated proximal lesions and inordinate lesion extension, this strategy has extensive restrictions.[3]

Minimally invasive techniques which are limited to the actual damage lessen the amount of destruction; usage of biomimetic restorative materials allows an adequate clinical and esthetic outcome, and in tandem, the intervention will enable regulation of the local microflora.[4]

Resin infiltrants penetrate through the porous structures of the lesion because of their low viscosity and high penetration, creating a diffusion barrier for cariogenic acids and helps to

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prevent lesion progression.[5,6] The refractive index of white spot lesions is around 1.33 or 1 as the porosities are filled with water or air respectively. Resin infiltrated lesions have a refractive index of 1.46 which make them appear similar to the surrounding enamel (refractive index of sound enamel is 1.6) making the difference insignificant. [2]

Micro abrasion technique comprises of application of acids and abrasive compounds to the surface of the spotted enamel.[8] When 5-10 applications of micro abrasives are used, this technique will result in loss of 25-200 microns of enamel. This technique is considered safe and conservative.[6] Changes in the optical characteristics of the enamel surface such as 'abrasion effect' are also visible in addition to the removal of discoloured enamel. When enamel prisms are eroded by abrasion and acid in synchrony, compact mineralized tissue replaces the outer layer of prism-rich enamel.[7]

The aim of this study is to evaluate the effect of resin infiltration and microabrasion on the surface roughness of incipient carious lesion to determine the resistance to demineralization.

***Subjects and Methods***

Ethical approval for this study (Protocol No: YEC2/891) was provided by the Yenepoya Ethics Committee 2, Yenepoya (Deemed to be University), Mangalore on 26 November 2021.
55 extracted human premolars, extracted for orthodontic purpose, were selected and thoroughly cleaned of debris and stored in saline solution until required. Each specimen was coated with varnish except for the middle third of buccal surface.

Lesion Formation: Each specimen was placed in 15ml of demineralizing solution (2.2mM CaCl2 0.05 M Lactic acid, 0.5ppm of Fluoride) adjusted to a pH of 4.5 with 50% of NaOH for 48 hours. At the end of 48 hours, chalky white incipient caries lesions were established on the surface of each specimen.42

To determine the degree of demineralization of enamel specimen, caries detection tool - DIAGNOdent was used.
The samples were divided into five groups (11 per Group):

Group I: This group was subjected to micro invasive procedure using Tetric N bond universal (Application Procedure: Enamel was etched for 30 seconds and rinsed for 30 seconds and air-dried for 30 seconds. Adhesive resin was applied for 30 seconds and lightcured for 30 seconds (600mW/cm2). This procedure was repeated and glycerine gel was applied and light-cured for 60 seconds. For further demineralization, all specimens in this group were again immersed in the demineralization solution for 48 hours.

Group II: This group was subjected to micro invasive procedure using ICON (DMG, Hamburg, Germany) (Application procedure: Enamel was etched for 120 seconds, rinsed for 30 seconds and air-dried for 30 seconds. Ethanol was applied for 30 seconds, and air-dried for 30 seconds. Resin was infiltrated for 180 seconds with rubbing and light-cured for 60 seconds (600mW/ cm2). Resin infiltrant application was repeated for 60 seconds, glycerine gel was applied and light-cured for 60 seconds. For further demineralization, all specimens in this group were again immersed in the demineralization solution for 48 hours.

Group III: This group was subjected to Micro abrasion without polishing using Oplaustre (Application procedure: A low-speed handpiece was used to apply slurry to enamel lesions for a period of 60 seconds, followed by a 30-second interval). For further demineralization, all specimens in this group were again immersed in the demineralization solution for 48 hours.

Group IV: This group was subjected to Micro abrasion with polishing using Opalustre Diamond Excel (Application procedure: A low-speed handpiece was used to apply slurry to enamel lesions for a period of 60 seconds, followed by a 30-second interval. Diamond paste using felt discs was applied with the aid of a low-speed hand piece for 30 seconds). For further demineralization, all specimens in this group were again immersed in the demineralization solution for 48 hours.

Group V: This group was placed in distilled water. For further demineralization, all specimens in this group were again immersed in the demineralization solution for 48 hours.

***Evaluation:*** Three specimens were selected from each group in two evaluation periods (after micro invasive procedure and further demineralization) and surface roughness was analyzed using stylus profilometer.

***Statistical Analysis***

All the data were collected and analysed using SPSS version 23.0. The level of significance was set at $p < 0.05$.One-way ANOVA is used for comparison of 5 groups (p value <0.05 is considered significant).Continuous variables were described in terms of mean and standard deviation. For the multiple comparison, Tukey's HSD test was used (p value <0.05 is considered significant).

## RESULTS

Comparison of surface roughness values of groups (After microinvasive procedures and Further demineralization) are given in Table 1 and show that there is a significant difference for the groups, after microinvasive procedures, ($F=426.369$ , $p <0.001$) and the groups after further demineralization ($F=226.316$, $p<0.001$).

**Table 1** Comparison of surface roughness values of groups (After microinvasive procedures and Further demineralization). AR=Adhesive Resin, RI=Resin Infiltration, MA=Microabrasion without polishing, MAP= Microabrasion with Polishing, CON= Control

| | Groups | Mean(S.D) | p value | 95% CI |
|---|---|---|---|---|
| After micro invasive procedure | AR | 0.029(0.006) | <0.001 | 0.025 to 0.034 |
| | RI | 0.041(0.007) | | 0.036 to 0.046 |
| | MA | 0.081(0.012) | | 0.073 to 0.090 |
| | MAP | 0.062(0.011) | | 0.055 to 0.070 |
| | CON | 0.173(0.006) | | 0.168 to 0.177 |
| Further demineralisation | AR | 0.061(0.013) | <0.005 | 0.052 to 0.071 |
| | RI | 0.066(0.012) | | 0.057 to 0.074 |
| | MA | 0.112(0.012) | | 0.103 to 0.120 |
| | MAP | 0.085(0.027) | | 0.067 to 0.104 |
| | CON | 0.245(0.012) | | 0.236 to 0.253 |

Furthermore, Multiple comparison by using Tukeys HSD test is given in Table 2. It was found that resin infiltration had lower roughness values than microabrasion, and that the values did not reach those of sound enamel. Further demineralization for 48 hours increased the roughness of infiltrated and microabraded enamel surfaces. In microabraded enamel surfaces, polishing did not affect the roughness.


**Fig 1** Materials used in the study. (A) Adhesive Resin – Tetric N bond Universal (B) Resin Infiltrant – DMG Icon – Caries infiltrant smooth (C) Microabrasion–Opalustre.

**Table 2** Multiple comparison by using Tukeys HSD test. AR=Adhesive Resin, RI=Resin Infiltration, MA=Microabrasion without polishing, MAP= Microabrasion with Polishing, CON= Control

| | Groups | | p value | 95% CI |
|---|---|---|---|---|
| After microinvasive procedure | AR | RI | 0.32 | -0.022 to -0.000 |
| | | MA | <0.001 | -0.063 to -0.041 |
| | | MAP | <0.001 | -0.044 to -0.021 |
| | | CON | <0.001 | -0.154 to -0.132 |
| | RI | MA | <0.001 | -0.051 to -0.029 |
| | | MAP | <0.001 | -0.032 to -0.010 |
| | | CON | <0.001 | -0.142 to -0.120 |
| | MA | MAP | <0.001 | 0.008 to 0.030 |
| | | CON | <0.001 | -0.102 to -0.080 |
| | MAP | CON | <0.001 | -0.121 to -0.099 |
| Further Demineralisation | AR | RI | 0.972 | -0.024 to 0.015 |
| | | MA | <0.001 | -0.070 to -0.030 |
| | | MAP | 0.012 | -0.044 to -0.003 |
| | | CON | <0.001 | -0.203 to -0.163 |
| | RI | MA | <0.001 | -0.066 to -0.026 |
| | | MAP | 0.058 | -0.039 to 0.000 |
| | | CON | <0.001 | -0.198 to -0.158 |
| | MA | MAP | 0.004 | 0.006 to 0.046 |
| | | CON | <0.001 | -0.152 to -0.112 |
| | MAP | CON | <0.001 | -0.179 to -0.138 |

## DISCUSSION

Dental caries is the process of vibrant interaction between the tooth surface and the plaque biofilm. The balance between mineral loss and gain can shift to favor either re- or demineralization so that early or non-cavitated carious lesions can be arrested or remineralized.[8] The early signs of the disease are the development of the so-called "white spots" or incipient carious lesions.[9]

The laser fluorescence method is a non-invasive method used in many in-vivo and in-vitro studies to evaluate white spot lesions, and it uses the red end of the electromagnetic spectrum with a 655 nanometer light wavelength (Diagnodent or Diagnodent pen, KaVo, Biberach, Germany).[4] The difference between the fluorescing capacity of the sound tooth and the carious tooth tissue can be recorded by the device. The difference in the properties of reflection, transmission, and color absorption between demineralized and healthy teeth affects the laser fluorescence reading, which helps detect caries. An explanation for the method's exact mechanism is that the red light stimulates a different wavelength of fluorescent light in tooth tissue due to a change in porosity. The second theory is that fluorescence depends on emission from the metabolites, such as porphyrins produced by cariogenic bacteria. The laser fluorescence device has been reported to detect artificial caries lesions induced without bacteria.[10] In this study, there were no significant differences in the values obtained with the laser fluorescence device among the groups for the initial demineralization period. As a result, the demineralization solution in the study produced uniform artificial carious lesions. As compared to baseline values, the laser fluorescence device measured significantly different values after demineralization. It could be related to an increase in the porosity of enamel and adequate detection of changes in mineral content by the device.

Even though the surface of the lesion remains relatively intact (pseudointact surface layer), white spot lesions are characterized by tiny pores within the lesion body of initial enamel caries. The pseudointact surface layer is removed by acid etching with hydrochloric acid as it could hamper the resin from penetrating into the lesion while using the resin infiltration technique.[11] White spot lesions can be either noncarious or carious. To differentiate between them, the clinician must first clean and dry the teeth and then closely evaluate the lesions using magnification and adequate lighting. The consistency and texture of the surface can be gently evaluated with a periodontal probe. Carious white spot lesions appear rough, opaque, and porous. Noncarious lesions appear mostly smooth and shiny.[12] To remove superficial discolorations and as a proposed treatment approach for the management of white spot lesions, hydrochloric acid in similar concentrations is used.[13] When the lesions are more superficial, enamel surface removal has been achieved with the resin infiltration technique compared to enamel microabrasion.

Resin infiltration technique not only leads to complete removal of the surface layer, but also increase the penetrability of low-viscosity light curing resins into the pores of incipient lesions, thereby protecting the lesion from further acid attacks. The lesion progression might be arrested and a mechanical support for the enamel lesion structure might be achieved following curing of the resin material. [14]

The microabrasion technique used with and without polishing of did not give a similar level of progress in surface roughness as did the resin infiltration technique used following an adhesive resin and an infiltrant. Determined to assess surface qualities, Incipient caries lesions with icon treated surfaces were compared to lesions with adhesive resin infiltrated surfaces. Since Tetric N bond Universal demonstrated greater penetration capability than other commercially available bonding agents, it was used to fill the artificial enamel lesions in this study. Tetric N bond showed the best roughness results with lower Ra values than those of the resin infiltrant. When infiltrating incipient lesions with resin infiltrant, surface roughness values were significantly lower than those after initial demineralization. The roughness of infiltrated lesions was however significantly higher compared to the roughness of sound enamel. Recent studies have found that resin infiltration does not affect the surface roughness of subsurface lesions, and that improvement of baseline surface roughness cannot be achieved by resin infiltration.[15]

In addition, the effects of finishing procedures on the surface roughness of infiltrated enamel lesions have been examined. The use of finishing strips after infiltration has not been found

to be advantageous regarding surface roughness. Taking these findings into account, it appears that resin infiltrants are capable of penetrating deeply into porous enamel lesions, but they cannot form a smooth coat on those surfaces. Thus, in clinical situations, microbial colonization of a subsurface lesion that has been infiltrated will result in further demineralization of the enamel, progress of the caries lesion, and increased roughness.[15] In recent years, a two-step treatment approach using a flowable composite as a resinous top coat has been recommended to improve the surface properties of lesions.

In this study, the microabrasion technique decreased the roughness of the enamel surfaces that were subjected to demineralization, but the difference in sound versus microabraded teeth (with or without polishing) was statistically significant. Until now, no studies have examined the effect of microabrasion on the characteristics of incipient carious lesions by roughness analysis. In comparison with sound enamel surfaces, a greater amount of superficial enamel roughness was previously reported after microabrasion treatment. The enamel microabrasions caused by the acid erosive action were responsible for roughness effects. Many studies have examined the potential erosive and abrasive effects of several parameters on the remaining enamel surface for microabrasion.[16]As regards different compounds (combinations of acids and abrasives) used for the technique, a tendency to reduce roughness has been reported when the final polish is performed using abrasive materials (diamond or aluminium oxide particles) to minimize the enamel surface roughness. In this study, a smoother enamel surface was obtained for the microabrasion group with polishing polished with diamond paste compared with that of the microabrasion group without polishing. The enamel surfaces polished with diamond paste were reported to have a similar morphology to that of normal enamel.

The roughness of both infiltrated and microabraded lesions increased following further demineralization in this study. In spite of this increase in surface roughness, both infiltration and microabrasion significantly reduced lesion progression compared with untreated control lesions. Infiltration with Tetric N bond did not result in better surface roughness or demineralization resistance compared with icon. Following further demineralization, no significant difference in roughness was found between the two microabrasion groups (MA and MAP), indicating that polishing did not significantly influence roughness of the lesion surfaces.

## CONCLUSION

Within the limitations of this study, the icon infiltration appeared to provide reduced roughness, although not equal to sound enamel. Further research is needed to elucidate their clinical relevance.

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