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Effect of resin infiltration on surface microhardness and surface roughness of normal surface enamel: In vitro study

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Abstract

Objective: The effect of resin infiltration over Surface Microhardness and Surface Roughness of normal enamel surface.

Material and Method: 60 enamel specimens were prepared from extracted teeth by mounted in 5x4x3 cm dimension of self-cure acrylic resin block to mount specimen on platform of tester. Surface Roughness was measured with Carl Zeiss handy surf tester and surface microhardness was measured with Rockwell hardness test. All the specimens were then subjected to resin infiltration treatment protocol and again both the tests were performed as pre operatively. Data was collected and subjected to statistical analysis using paired t test.

Result: No difference found in Surface microhardness test with statistically insignificant result (p value >0.05). However, statistically significant result (p value <0.05) was present in relation to surface roughness suggesting smoother surface after resin infiltration.

Conclusion: Resin infiltration decreases surface roughness but surface microhardness does not have any significant changes.

Keywords: Resin Infiltration, Surface Microhardness, Surface Roughness, Carl Zeiss handy surf tester, Rockwell hardness test.

Introduction

Most common chronic disease of the teeth though out the world is dental caries Worldwide Different

approaches for caries removal have been attempted through the years. It starts with Mineral loss in the surface or subsurface enamel leading to an optical phenomenon of white spot lesion. Mineral loss is one of the causes for initial step in development of a carious lesion, which later on develops into subsurface lesion in presence of fluoride. Some of the studies suggested that white spot lesions may regress or even disappear as a result of remineralization from the oral fluids.

Hydroxyapatite in sound enamel has a refractive index (RI) of 1.62.[2] When a WSL is hydrated with saliva, the RI of saliva within the enamel porosities is 1.33. This discrepancy in RI between saliva and hydroxyapatite affects light scattering and makes the WSL look slightly opaque (Image 1). When teeth are dried, saliva is replaced with air (RI = 1.0) within the WSL porosities. The WSL are more evident in dehydrated teeth due to wider difference in RI between air and hydroxyapatite than saliva and hydroxyapatite. The ability of replacing air in the demineralized enamel of WSLs with a material with RI similar to that of hydroxyapatite, such as a methacrylate resin, has shown to mask the WSL by preventing light from scattering inside the WSL. Unsupported enamel crystalline in the body of WSL can be reinforced by resin incorporation in the porosities. This reinforced enamel becomes mechanically stronger and more resistant to acid dissolution.

White Spot Lesion is indeed a continuing problem in the practice of orthodontics as well early sign of dental caries. White spot lesions (WSL) may not be harmful for individual in terms of function but may be aesthetically unacceptable to some individuals and seek treatment for the same.

Microhardness of the enamel surface treated with Icon was approximately the same as that of the sound enamel. The treated enamel showed a clinically acceptable surface roughness, indicating that this infiltrant might be suitable for the treatment of enamel subsurface lesions.[6]

This research was done to analyze the effect of resin infiltration on Surface Roughens and Surface Microhardness on normal enamel surface through Carl Zeiss handy surf tester and Rockwell hardness test respectively. With this background the present study was conducted with the null hypothesis that there is no difference in the Surface Microhardness and Surface Roughness of normal surface enamel with treatment with resin infiltration technique.

Materials and Methods

The materials tested in this study were Icon – Smooth Surface (resin infiltrant) (DMG, Germany).

Sample preparation

A total of 30 caries-free freshly extracted teeth were thoroughly cleaned using slurry pumice with a prophylaxis brush in a contra angled handpiece. Teeth used in this study were collected and stored in a thymol solution (0.025%) until the day of measurement. Teeth having no cracks, restorations, or developmental lesions were selected. A total of 60 specimens were embedded in self-cure acrylic resin in a manner that the crown was projected and ensuring that the convex smooth tooth surfaces were parallel to the scanning stage to the maximum (Figure 1). All specimens were stored in distilled water once the measurements were taken. Two groups of 30 specimens were measured for their Rockwell surface hardness (HRL) with an Indentron Rockwell Hardness Testing System) (Figure 2) and for their surface roughness with a surface profilometer (Carl Zeiss – handy surf surface roughness tester) (Figure 3). Each specimen acted as its own control. Measurements were taken before and after the application of the resin infiltrant material according to the manufacturer's instructions.

Figure 1: Samples in acrylic mount

Measurement of Enamel Surface Hardness

Surface hardness measurements were made using a microscope with 200· magnification. The test was performed by applying a load of 300 g to the specimens for 15 s. The load and time were constant for all the samples throughout the study. Measurements after surface treatments of both materials were delayed for 24 h and for the teeth were kept in an incubator in distilled water at 37^{O}C. Three indentations were made in each specimen before and after surface treatment. To ensure accuracy of the measurements, indentations were done on the flattest points of the enamel surface.

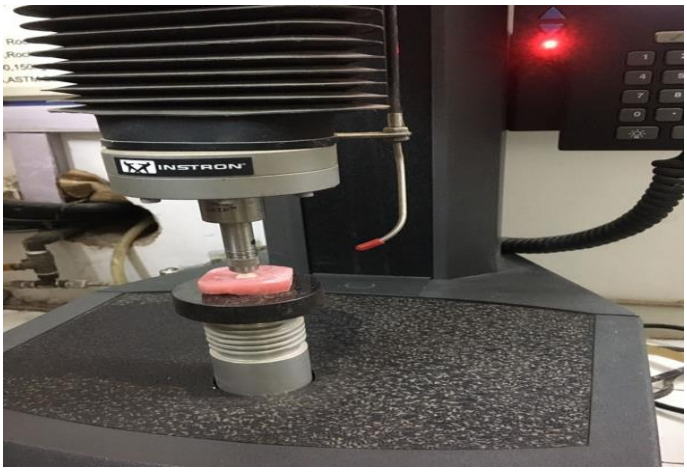


Figure 2: Indentron Rockwell Hardness Testing System

Measurement of Enamel Surface Roughness

Surface roughness was characterized by the average roughness (Ra), which represents the arithmetical average value of all absolute distances of the roughness profile from the canter line within the measuring length (Whitehead et al., 1995). Three readings were recorded on each surface. The cut-off value (distance transverse by the stylus over which the data were collected) for surface roughness was 0.6 mm. The influence of resin infiltration system on enamel microhardness and surface roughness: In vitro study 81 distance of the stylus was 5.0 mm. The radius of the tracing diamond tip was 0.5 mm, measuring force was 10 mN, and speed was 2 mm/s. The machine was calibrated after every five samples to ensure reliable readings.

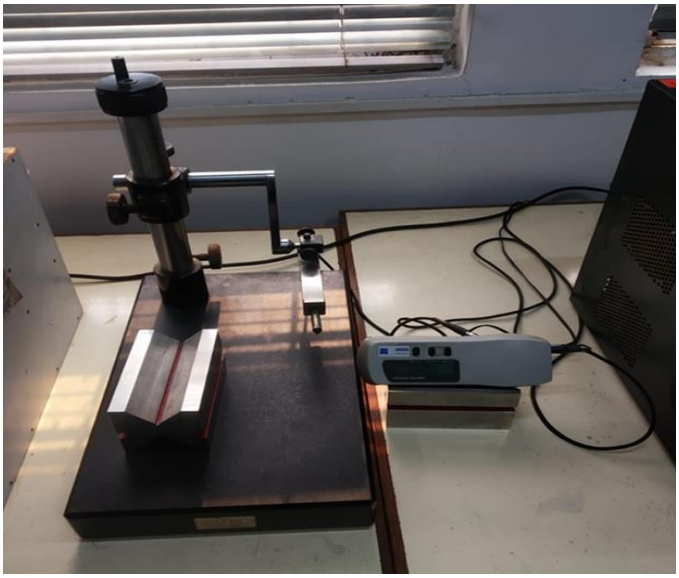


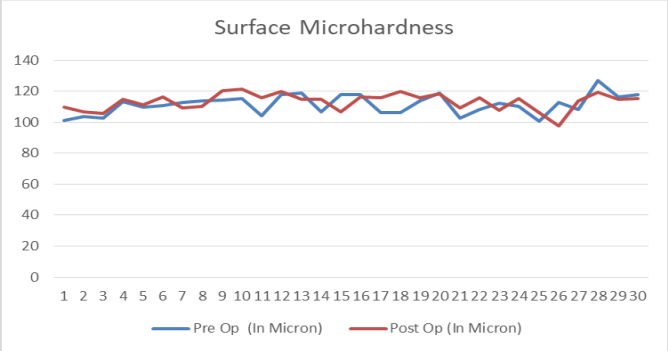
Figure 3: Carl Zeiss – handy surf surface roughness tester

Statistical Analysis

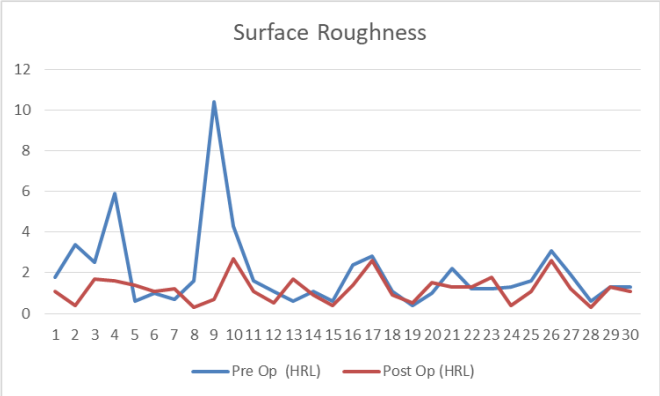
For each measured parameter, mean values were calculated before and after treatment were compared with a dependent t-test. All analyses were performed with the SPSS program version 16 (USA). Differences with a P-value of 0.05 were considered statistically significant.

Results

The Observed data is represented as a graphical presentation in graphs 1 and 2 for Surface Microhardness and Surface Roughness respectively.



Graph 1: Data summary of Surface Microhardness



Graph 2: Data summary of Surface Roughness

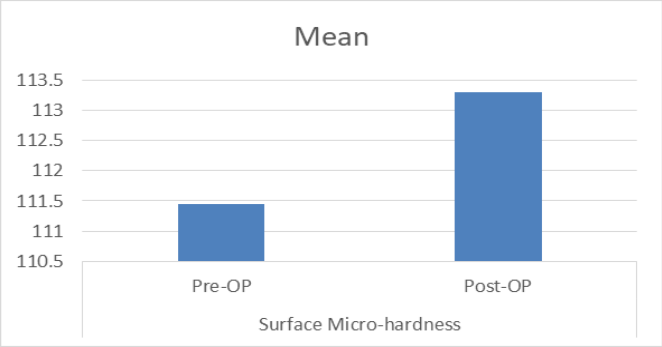
The sample size calculations were based on the basis of our pilot study. As per prevalence from the pilot study with 98.34%, 26 subjects required for this study with an accepted alpha error of 95 and power of study of 90. No significant differences in the enamel's surface microhardness were found before and after the application of the resin infiltrant (Table 1). Statistical difference in surface roughness was found between before and after application of Resin inifltration material to sound enamel (Table 1). Significantly smoother surface values were recorded for surfaces treated with infiltrant (6.5 ± 1.85). The mean value of both tests is depicted in graphs 3 & 4.

Table 1: Paired Samples Test

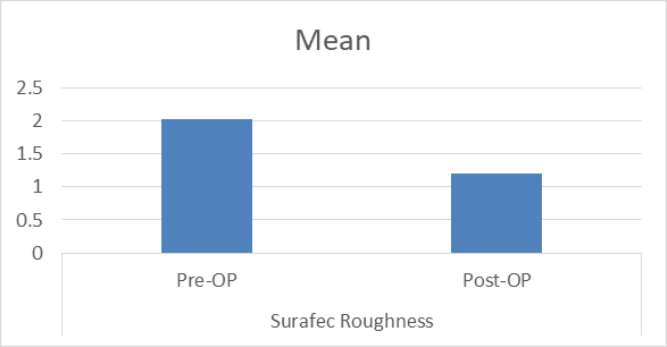
		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
					Lower	Upper				
Surface Microhardness	Pre-OP - Post-OP	-1.8533	6.5698	1.1995	-4.3065	0.5999	-1.545	29	0.067	0.133
Surface Roughness	Pre-OP - Post-OP	0.8167	1.9844	0.3623	0.0757	1.5577	2.254	29	0.016	0.032*

P value <0.05: Statistically insignificant

*: P value > 0.05 : Statistically significant



Graph 3: Mean Surface Microhardness



Graph 4: Mean Surface Roughness

Discussion

Resin infiltration treatment protocol which is a non-invasive treatment leading to a conservative as well as the preferable method by many for white spot lesions & initial carious lesions present on the teeth clinically as well as the purpose of this study worldwide.

In white spot lesions, white opacities which are opaque are observed on the enamel surface of the teeth. This is because the sub-surface layer of the enamel in the teeth becomes demineralized, usually due to bacterial action on the teeth, acid deposits, poor oral hygiene, etc. The ability to detect artificial caries lesions induced without bacteria by the laser fluorescence device has also been reported.

In this study, the sound enamel surface was evaluated for resin infiltration technique regarding surface roughness and surface microhardness. In the white spot lesions of teeth, there is sub-surface demineralization present with the topmost layer being comparatively intact which can be named the pseudo-intact surface layer.

This pseudo-intact surface layer can cause hindrance in infiltration of the resin material used in the resin infiltration treatment protocol and therefore etching with the acid of the surface becomes a necessity so as to break the pseudo-intact surface layer prior to giving the resin infiltration treatment using the resin infiltration technique. In subsurface porosity, the surface roughness and surface microhardness decrease and increase respectively.

Hydrochloric acid, can also be used for the purpose to treat white spot lesions in the aspect of aesthetic dentistry to remove superficial discolorations and as a proposed treatment approach for the management of white spot lesions using enamel micro abrasion, resin infiltration technique does not lead to the complete removal of the pseudo-intact surface layer of the enamel hence, protecting the enamel surface from the acid attacks. It works on the principle of increasing infiltering of low viscosity light curing resin into the pores of incipient lesions rather than complete removal of the pseudo-intact surface layer. Additionally, this can also lead to stoppage or arrestment of the lesion progression underneath the surface enamel along with providing mechanical strength to the previous or pre-treated tooth structure. Such micro-invasive treatment of incipient caries has been recently shown to significantly reduce mineral loss after demineralization challenges and to arrest artificial enamel lesions compared with untreated lesions. The previous approach to infiltrate the artificial and natural enamel lesions using infiltrants with differing penetration coefficients showed that the resin infiltrants with high penetration coefficients were able to penetrate more deeply into subsurface lesions.

In this study, it was found that there were almost nearly no changes observed in micro-hardness of the enamel surface keeping in mind that the enamel surface used for this study is that of sound tooth structure.

Paired t-test was used to test the Null hypothesis before and after comparisons of Surface Roughness and Surface, Microhardness was made. For Surface Roughness the P value for the statistical test was observed to <0.05, we could reject the hypothesis concluding that there was a significant difference in Surface Roughness due to Resin infiltration on Normal Surface Enamel. For Surface Microhardness the P value for the statistical test was observed to >0.05, we could not reject the hypothesis concluding that there was no significant difference in Surface Microhardness due to Resin infiltration on Normal Surface Enamel and the changes are observed are by chance only.

One should make a note that the mechanical property of the micro-hardness of the enamel surface post-treatment can be influenced by the degree of demineralization present in the white spot lesion of the teeth prior to pre-treating or initially. Hence, microhardness which is almost the same for pre and post-treated enamel of sound tooth can differ from tooth to tooth depending upon the degree of demineralization of white spot lesions of each and every tooth. The surface roughness generally decreases after resin infiltration giving a smoother touch on the enamel surface generating no negative impact on the tooth.

Conclusion

Within the limitations of this current study, it was concluded that:

1) Surface Microhardness of normal enamel does not have a predictable impact.
2) Post-operative normal Surface roughness is reduced by this treatment modality.

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