Enamel Surface Evaluation after Removal of Orthodontic Composite Remnants by Intraoral Sandblasting Technique and Carbide Bur Technique: A Three-Dimensional Surface Profilometry and Scanning Electron Microscopic Study

Amol C Mhatre1, Arundhati P Tandur2, Sumitra S Reddy3, B C Karunakara4, H Baswaraj5

Contributors:
1Lecturer, Department of Orthodontics, MGM Dental College and Hospital, Navi Mumbai, Maharashtra, India; 2Professor and Head, Department of Orthodontics, Narsinhbhai Patel Dental College, Visnagar, Gujarat, India; 3Professor and Head, Department of Orthodontics, KLES’ Institute of Dental Sciences, Bengaluru, Karnataka, India; 4Professor, Department of Orthodontics, KLES’ Institute of Dental Sciences, Bengaluru, Karnataka, India; 5Professor, Department of Orthodontics, Narsinhbhai Patel Dental College, Visnagar, Gujarat, India.

Correspondence:
Dr. Mhatre AC. A/12, LIL CHS, Maratha Bhavan Marg, Sector 14, Vashi, Navi Mumbai - 400 703, Maharashtra, India. Tel.: +922-3237154/022-27669451. Email: dr.mhatre.amol@gmail.com

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Abstract:
Background: The purpose of this thesis is to present a practical and efficient clinical method of returning enamel to as near its original condition as possible following removal of bonded orthodontic attachments. The main objective of this study is to evaluate and compare the iatrogenic enamel damage caused by use of two different remnant removal techniques – sandblasting technique and carbide bur technique.

Materials and Methods: 40 extracted premolar teeth were selected as sample. Premolar brackets were bonded on these teeth with two different types of light cure adhesive composite resin. The remnants present on these samples after debonding the brackets were removed with two different types of remnant removal techniques namely – Carbide bur technique and sandblasting technique. Then these treated surfaces were studied under Scanning electron microscope and three-dimensional profilometer for the damage caused to the enamel. Statistical analysis used: Student’s t-tests.

Results: The enamel surface structure after remnant removal with intraoral sandblasting is better than that after removal with a low-speed handpiece using tungsten carbide bur.

Conclusion: Sandblasting can be an acceptable alternative to rotary handpieces to restore the enamel surface to its near-original state and prevent permanent damage to the tooth.

Key Words: Enamel surface, composite remnants, intraoral sandblasting, three-dimensional profilometry

Introduction
The concept of bonding resins to enamel has developed applications in all fields of dentistry, including orthodontics. Composite bonding of orthodontic attachments to enamel surfaces has had a significant, if not revolutionary, impact on clinical orthodontic treatment. Although the advantages of bonding clearly outweigh the disadvantages, some concerns remain. The primary orthodontic goal lies in returning the enamel surface to its original state after removal of orthodontic attachments. Damage to enamel can be attributed to cleaning with abrasives before etching, acid etching, enamel fractures caused by forcibly removing brackets, or mechanical removal of remaining composite with rotary instruments. Introduction of the acid-etch technique for bonding orthodontic attachments has proven to be a landmark advancement in clinical orthodontic treatment and the literature is replete with related reports.

The purpose of this study is to evaluate these concerns and to present a practical and efficient clinical method of returning enamel to as near its original condition as possible following removal of bonded orthodontic attachments. The main objective of this study is to evaluate and compare with three-dimensional (3D) profilometry the iatrogenic enamel damage caused by use of two different remnant removal techniques – Sandblasting technique and carbide bur technique using two different light cure composite resins (bracket bonding agents).

Materials and Methods
A total of 40 premolars extracted for orthodontic treatment purpose with healthy crown structure without any kind of dental treatment performed over it, no damage caused by extraction forceps and no caries were chosen.

They were separated into two groups – Group A and Group B with 20 samples each. The cleaned buccal surface was etched for 20 s by using 37% phosphoric acid (Viscous Etch red, OrthoSource, Cat. No. S57 415, USA). Teeth that do not appear dull and frosty white were re-etched.

Single layer of 3M Unitek Transbond™ light cure adhesive primer was applied on the teeth in Group A. Minimal amount of 3M Unitek Transbond™ light cure adhesive composite was applied on the base of the premolar bracket (0.022 MBT 3M UNITEK; GEMINI SERIES) having meshwork for retention
purpose. Bracket was positioned properly over the buccal surface, flash carefully removed and cured for 20 s using T-light emitting diode light curing gun (frequency range 450-470 nm).

For Group B minimal amount of Heliosit® orthodontic ivoclar vivadent (resin-based dental luting material for brackets) light cure adhesive composite is applied on the base of the bracket. This adhesive composite is composed of primer as well composite resin. The bonding procedure was done in the same manner as for Group A.

Bracket was debonded with the help of debonding plier. Straight fissured short adhesive remnant removal carbide bur REF H22GK (KOMET® GEBR. BRASSELER, Germany) was used for removing the remnants. Complete removal of the resin adhesive was verified by visual inspection under a dental operating light.

This remnant removal treatment was given to 10 samples randomly selected from Group A and 10 samples from Group B. Later the remaining 10 samples from each group were taken for remnant removal with the in-vivo sandblaster technique. Microetcher II intraoral sandblaster (Danville materials, California) was used.

These samples along with control (untreated) and etch treated Figure 1 tooth were studied under 3D optical profilometer (WYKO Surface Profiler). The software used was of Veeco Metrology group, United States.

**Statistical analysis**

**Statistical methods**

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on mean ± standard deviation (minimum-maximum) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. Student’s t-test (two-tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups inter group analysis).

1. Student’s t-test (two-tailed, independent)

\[
t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{s^2(1/n1 + 1/n2)}}
\]

\[
= \frac{(n1-1)\sum(x1-x1)^2 + (n2-1)\sum(x2-x2)^2}{n1 + n2 - 2}
\]

Where, \(s^2 = \frac{(n1-1)\sum(x1-x1)^2 + (n2-1)\sum(x2-x2)^2}{n1 + n2 - 2}\)

2. Significant figures

+ Suggestive significance (P value: 0.05 < P < 0.10)

* Moderately significant (P value: 0.01 < P ≤ 0.05)

** Strongly significant (P value: P ≤ 0.01)

**Statistical software**

The statistical software namely SPSS 15.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

**Study design: A comparative study**

Comparison of average roughness, root mean square (RMS) roughness and maximum height of the surface in samples when treated with carbide bur Figure 2 and treated with sandblasting Figure 3 for Heliosit® orthodontic ivoclar vivadent (resin-based dental luting material for brackets) light cure adhesive composite was done by studying the surface profile under 3D profilometry.

Results of the surface profile measurement for each group are summarized in Table 1.

The Student’s t-test (two-tailed, independent) for the arithmetic average value of the profile departure from the mean line in the sampling length \(R_a\) (\(R_a\) – Average roughness, Rms – Root mean square roughness, \(R_m\) – Maximum height of the surface).

![Figure 1: Etched tooth surface.](image1)

![Figure 2: Heliosit® orthodontic ivoclar vivadent (resin-based dental luting material for brackets) light cure adhesive composite sample treated with carbide bur.](image2)
the arithmetic mean of the absolute values of the surface departures from the mean plane. \( R_a \) is normally used to describe the roughness of machined surfaces) indicated strongly significant differences among the two groups \((P \leq 0.01)\). Similarly statistically strongly significant differences among the two groups \((P \leq 0.01)\) is observed for the parameters \( R_q \) (\( R_q \) represents the RMS roughness, obtained by squaring each height value in the dataset, then taking the square root of the mean. RMS roughness is generally used to describe the finish of optical surfaces. It has statistical significance because it represents the standard deviation of the surface heights, and it is used in the more complex computations of skew and kurtosis) and \( R_t \) – Maximum height of the surface which is the vertical distance between the highest and lowest points as calculated over the entire dataset.

Thus the Student’s \( t \)-test analysis showed that there was significantly lesser amount of overall roughness that is caused to the enamel surface because of sandblasting technique as compared to carbide bur technique used for removal of remnants of Heliosit composite resin (Graph 1).

Comparison of average roughness, RMS roughness and maximum height of the surface in samples when treated with carbide bur Figure 4 and treated with sandblasting Figure 5 for 3M Unitek Transbond™ light cure adhesive composite resin.

Results of the surface profile measurement for each group are summarized in Table 2.

The Student’s \( t \)-test (two-tailed, independent) for the arithmetic average value of the profile departure from the mean line in the sampling length \((R_a)\) indicated suggestive significant differences among the two groups \((0.05 < P < 0.10)\). Similarly statistically moderately significant differences among the two groups \((0.01 < P \leq 0.05)\) is observed for the parameters \( R_q \) – RMS roughness which is obtained by squaring each height value in the dataset, then taking the square root of the mean. The analysis for the parameter \( R_t \) – Maximum height of the surface which is the vertical distance between the highest and lowest points as calculated over the entire dataset showed strong statistically significant difference \((P \leq 0.01)\).

Thus the Student’s \( t \)-test analysis showed that there was significantly lesser amount of overall roughness that is caused to the enamel surface because of sandblasting technique as compared to carbide bur technique used for removal of remnants of Heliosit composite resin (Graph 2).
confirmation of varied surface roughness pattern. Figure 6a shows control tooth surface, Figure 6b shows etched tooth surface, Figure 6c shows tooth surface treated with carbide bur whereas Figure 6d shows tooth surface treated with carbide bur.

**Discussion**

The resulting characteristics of enamel surfaces after remnant removal between the composite removal tungsten carbide bur using low-speed handpiece and the new method of intraoral sandblasting were compared. The former method has a disadvantage, because water coolant results in poor contrast between resin remnant and enamel whereas sandblasting for removal of resin remnants did not cause pulpal damage. The vibration of the low-speed handpiece during resin remnant removal can be uncomfortable for the patient. Sandblasting did not vibrate the tooth during remnant removal. The temperature change is not taken into consideration in our study.

There are other few studies which used various methods to compare enamel surfaces after remnant removal: SEM,
visual inspection by photography, and adhesive remnant index.\textsuperscript{15-17} However, most of them did not compare enamel surface textures. To compensate for this limitation, we used 3D profilometric analysis with a profilometer in this in-vitro study. This provided quantitative data in a micrometer scale.

Although correlation coefficients ($r$) between the parameters for the remaining adhesives and the adhesive remnants index (ARI) scores varied by the parameters, all four parameters in a study\textsuperscript{19} showed significant correlations between the ARI scores. This reflects the fact that the ARI score is a general and rough estimation of remaining adhesive on the enamel surfaces; therefore, further subgrouping is recommended.\textsuperscript{18} The ARI scores of this study fell in all the categories for both the composite resins with the maximum samples for score 2. Since the method of debonding the brackets used was manual and also taking the previous studies into considerations,\textsuperscript{12,18} it cannot be concluded that whether a particular composite resin is better than the other on the basis of ARI.

Pus and Way\textsuperscript{19} found that a low-speed handpiece with a tungsten carbide bur removes approximately 10 $\mu$m of enamel, whereas Thompson and Way\textsuperscript{20} showed that an average of 14.2 $\mu$m of enamel was lost when prophylaxis with zirconium silicate was performed with a rotating bristle brush.

Although resin remnant-removal procedures cause deterioration of the enamel surface, no clinical problem was caused, because the enamel surface layer contained a fluoride-rich layer of 50 $\mu$m depth.\textsuperscript{12}

According to the results seen in Tables 1 and 2, it can be concluded that there is statistically significant difference between the tungsten carbide bur technique and sandblasting technique. In this study the results show that there is overall lesser amount of roughness created by the sandblasting remnant removal technique than the carbide bur technique. In contrast, the study done by Kim et al.\textsuperscript{12} shows that the overall average roughness caused by sandblasting technique is more as compared to low-speed handpiece technique. We have achieved the similar results in both Heliosit® and Transbond™ composite resins.

However, the amounts of enamel loss supported that the $R_z$ values of this study were more than those of previous studies in a clinical situation. The lesser $R_z$ values for sandblasting technique suggest that lesser penetration is caused over the enamel surface.

Along with the introduction of novel methods, conventional instruments have been developed, such as specially designed burs, which are less aggressive to the enamel.\textsuperscript{21}

The most common removal technique uses ultrasonic scalers, a low-speed handpiece with a tungsten carbide bur, and a high-speed handpiece with a diamond bur.\textsuperscript{13,22,23} The most preferred method is to use a low-speed handpiece with a round tungsten carbide bur.\textsuperscript{24} This technique, however, is time-consuming and inefficient, and can damage tooth enamel.\textsuperscript{25}

Gwinnett and Gorelick\textsuperscript{26} evaluated the different methods of polishing enamel and concluded that polishing with a green rubber wheel followed by pumice or composite finishing paste came closest to restoring the enamel surface to its original quality.

Retief and Denys recommended using a 12-bladed tungsten carbide bur at high speed with adequate air cooling.\textsuperscript{24}

Zachrisson and Artun\textsuperscript{24} employed the replicating stereomicroscope and the SEM and concluded that a tungsten carbide bur at low speed produced the finest scratch pattern and the least enamel loss.

It is quite clear from a perusal of the literature that a variety of opinions exist concerning methods of resin removal and the subsequent enamel polishing. In reevaluating these techniques, it is incumbent upon the clinician to select the modalities which return the enamel surface to as near its original condition as possible with the least amount of enamel scarring and loss. The clinical appearance of the enamel, even when dry, should be pleasing.

When we compare these results with the study done by Kim et al.\textsuperscript{12} it can be concluded that remnant removal procedures followed are technique sensitive. The forces used for debonding the brackets may not be the same for each sample. Therefore further standardization of debonding procedure is required so as to achieve better and reliable results with respect to the amount of remnants for each composite resin.

**Conclusion**

Our results suggest that the enamel surface structure after remnant removal with intraoral sandblasting is better than that after removal with a low-speed handpiece using tungsten carbide bur. Sandblasting remnant removal has advantages for maintaining pulpal health and patient comfort.\textsuperscript{12} Since the time required for both the remnant removal techniques is not taken into consideration; the feasibility of using sandblasting technique in the clinics with respect to time consumed for the procedure cannot be commented upon. According to Kim et al.\textsuperscript{12} with a specially designed device for protecting operator and patient, sandblasting can be an acceptable alternative to rotatory handpieces for restoring the enamel surface to its near-original state and prevent any permanent damage to the enamel.

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