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ORIGINAL ARTICLE

Evaluation of Enamel Surface Roughness after Various Finishing Techniques for Debonding of Orthodontic Brackets

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ABSTRACT

Objective: The aim of this study was to evaluate the surface roughness of enamel after debonding with various types of burs.

Methods: The buccal surfaces of 20 mandibular incisors for each group of bur were subjected to profilometer analysis, and three parameters of surface irregularity were recorded. After bracket debonding, adhesive remnants were removed by tungsten carbide burs in low-speed, high-speed, and stainbuster settings. The samples were evaluated at pre-treatment (on sound enamel) (T1) and post-treatment (T2) by a profilometer. The specimens were measured twice, and the mean values were recorded.

Results: The results were analyzed in intra-group comparisons with paired t-tests and in inter-group comparisons with one-way ANOVA and Tukey's HSD test. All resin removal techniques significantly increased enamel surface roughness ($p<0.05$). According to one-way ANOVA, there were significant differences in the effect of enamel surface roughness between all methods ($p<0.05$). The high-speed bur caused the maximum roughness values and the stainbuster bur caused the minimum roughness values in all the parameters (Ra, Rz, and Rq).

Conclusion: The three types of burs used for finishing methods revealed significant differences in the enamel surface after debonding. However, the stainbuster bur created smoother surfaces than the other applied methods.

Keywords: Debonding, enamel surface roughness, profilometer, removal of resin

INTRODUCTION

Nowadays, people give more importance to their esthetical appearance because of both esthetic and technological developments in orthodontic materials and improvements in the socioeconomic status. As a result of this fact, orthodontic treatment becomes popular in the modern society. After the completion of orthodontic treatment, fixed appliances and bonded brackets must be mechanically removed; this is called debonding.

The aim of bracket debonding is to clear away applied attachments and adhesive resin from tooth surfaces without causing enamel detriment and to restore the enamel surface as close as possible to its pretreatment condition.[1, 2] Irregular and rough areas on tooth surfaces can cause enamel staining and plaque accumulation.[2] Removing the adhesive prevents enamel staining and potential plaque retention and restores the esthetic appearance of the enamel surface. During this process, enamel loss or irreversible enamel damage can occur.[2-9]

Continuous development of new materials and new techniques has been recorded in debonding methods to achieve minimal iatrogenic damage, e.g., air-flow, different types of burs, Sof-Lex discs, ultrasonic devices, and lasers.[9-13] In orthodontic clinics, the most frequent technique for debonding is to use burs. Tungsten carbide burs are used in low- or high-speed settings. Innovative finishing carbide bur, fiber-reinforced composite bur, and stainbuster bur handpieces have been frequently used.[11, 14-17] Bur choice is an important factor to consider when working on the enamel surface in a damage-free manner. Comparison of the various studies conducted on this topic shows no consensus as to which bur causes less damage.

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To examine the material surface visually, profilometery, atomic force microscopy (AFM), or scanning electron microscopy (SEM) techniques can be used. SEM cannot quantitatively evaluate the surfaces. The photomicrograph is unreliable and subjective; therefore, it only provides a surface image.[18] AFM and profilometer can be used especially when multiple mechanical scans are recommended for analysis of the average surface roughness and depth.[19] Although AFM provides images and measurements of surface roughness, in our study, a profilometer was preferred for its cost and accessibility. The aim of this *in vitro* study was to evaluate of roughness of the enamel surfaces with a profilometer after debonding with various types of burs.

METHODS

Prior to this study, a power analysis was performed with G*Power (version 3.1.10; Franz Faul, Christian-Albrechts University, Kiel, Germany) to estimate the sample size. The analysis indicated that a sample of 20 teeth for each group would yield more than 75% (actual power 0.776) power to detect significant differences with a 0.40 effect size at an α=0.05 significance level.

Sample Preparation

Sixty human mandibular incisors (teeth), newly extracted for orthodontic treatment, were used in this study. Teeth were selected on the basis of microscopic observation of the sturdiness of teeth surfaces, which was having no caries, no cracks, no abrasions, no white-spot lesions and no restorations on the coronal part. The teeth were embedded in acrylic resin and were kept in distilled water at room temperature during the time of the experiment in order to prevent dehydration. Teeth were cleaned, pumiced, and rinsed with water, then randomly divided into three experimental groups of twenty according to the adhesive remnants remover: tungsten carbide burs in low speed, tungsten carbide burs in high speed, and stainbuster bur.

Measurement of Surface Roughness

The average surface roughness (R_a), average roughness depth (R_z), and root mean square roughness (R_q) of all teeth were evaluated with a profilometer (Mitotoyo Surf Test SJ 201 P / M; Mitutoyo Corporation, Tokyo, Japan) before bonding (on sound enamel) (T_1) and after debonding (T_2) three times in every period and the mean values were evaluated. A diamond stylus (tip radius, 5 µm) acted across the surface under a constant load of 0.75 mN with a speed of 0.5 mm/s and a range of 350 µm to measure the roughness profile value in micrometers. Prior to measuring, the profilometer was calibrated against a reference block. Three tracings at three locations in different positions for each sample were recorded and the mean values were calculated. The obtained values were entered into a spreadsheet for calculation of descriptive statistics.

Bonding, Debonding, and Clean-Up Procedures

After the initial profilometer measurements were recorded, the teeth were etched with 37% phosphoric acid gel (3M™; 3M ESPE, St. Paul, MN, USA) for 20 seconds and were thoroughly rinsed with water and air dried. In total, sixty mandibular incisor brackets (Dentaurum; Ispringen, Germany) were bonded randomly with adhesive resin (Transbond XT; 3M Unitek, St. Paul, MN, USA) to all teeth surfaces. After removal of excess resin, the adhesive resin was photo-cured for 20 seconds using an LED unit (Elipar™ S10 LED Curing Light; St. Paul, MN, USA). All samples were stored in distilled water for 24 h at room temperature and the brackets were debonded with pliers (Dentaurum; Ispringen, Germany).

After debonding, the teeth were divided into three experimental groups of twenty, according to the adhesive remnants remover. In the first group, a 12-blade tungsten carbide finishing bur (Komet; Gebr Brasseler, Lemgo, Germany) with a low-speed contra-angle handpiece was used. In the second group, a 12-blade tungsten carbide finishing bur (Komet; Gebr Brasseler, Lemgo, Germany) with a high-speed contra-angle handpiece (above 25.000 rpm) was used. And in the third group, a stainbuster bur (Abrasive Technology; Lewis Center, Ohio) with a contra-angle handpiece (less than 10.000 rpm) was used. A new bur was used after every tooth and the polishing was continued until all adhesive remnants were cleaned from the surface. The time required for the completion of the resin removal protocol was recorded in seconds. Removal of remnant adhesive and restoration of the enamel surface, as close as possible, to inception was confirmed by visual inspection. Then, second profilometer measurements were recorded. All bonding, debonding, and clean-up procedures were performed by the same operator (MA).

Statistical Analysis

For the statistical analysis, the normal distribution of the data was confirmed by the Kolmogorov-Smirnov test and the homogeneity of variances was confirmed by the Levene's test. Then, the paired t-test was performed to evaluate the surface roughness on teeth yielded by the various treatments in intra-group comparisons. One way analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) tests were used to compare the effects of the various treatments on the surface roughness values among the groups in inter-group comparisons ($p<0.05$).

RESULTS

Surface roughness measurements (µm) according to surface treatments used for each group are summarized in Table 1. All resin removal techniques produced significantly rougher surfaces in comparison to the sound enamel for Ra, Rq, and Rz parameters ($p<0.05$). Regarding Ra values, the high-speed tungsten carbide bur group increased surface roughness from 0.63±0.09 µm to 2.45±0.34, the low-speed tungsten carbide bur group increased surface roughness from 0.59±0.11 µm to 1.67±0.25 µm, and the stainbuster bur group increased surface roughness from 0.66±0.08 µm to 1.13±0.23 µm. The duration of resin removal methods is presented in Table 2, according to the duration of resin removal, use of the stainbuster bur was more time consuming than the tungsten carbide bur.

According to the one way ANOVA, there were significant differences between all methods on enamel surface roughness for Ra, Rq, and Rz parameters ($p<0.05$). Multiple comparisons showed that the tungsten carbide bur groups had significantly greater irregularities when compared with the stainbuster bur group

Table 1. Descriptive statistics and results of paired t-tests

		Ra				
		Pre-Treatment		Post-Treatment		
Groups	n	Mean±SD	Min–Max	Mean±SD	Min-Max	p
High-Speed TC Bur	20	0.63±0.09	0.47–0.78	2.45±0.34	1.96–3.02	0.000***
Low-Speed TC Bur	20	0.59±0.11	0.44–0.79	1.67±0.25	1.31–2.05	0.000***
Stainbuster Bur	20	0.66±0.08	0.50–0.82	1.13±0.23	0.89–1.42	0.001**
		Rq				
High-Speed TC Bur	20	1.13±0.16	0.93–1.30	2.11±0.17	1.91–2.38	0.000***
Low-Speed TC Bur	20	1.19±0.14	0.95–1.37	1.85±0.21	1.59–2.13	0.001**
Stainbuster Bur	20	1.22±0.13	0.98–1.39	1.46±0.15	1.26–1.72	0.013*
		Rz				
High-Speed TC Bur	20	1.93±0.33	1.48–2.60	3.45±0.40	2.89–4.07	0.000***
Low-Speed TC Bur	20	1.86±0.35	1.40–2.52	2.93±0.43	2.39–3.72	0.000***
Stainbuster Bur	20	1.90±0.29	1.51–2.49	2.34±0.36	1.97–2.88	0.001**

Paired-samples t test for parametric data and Wilcoxon sign rank test for nonparametric data were used.
Ra: average surface roughness; Rq: root mean square roughness; Rz: average roughness depth; SD: standard deviation.
*p<0.05; **p<0.01; ***p<0.001

Table 2. Duration of resin removal methods used in the study

Groups	n	Mean	Min	Max
High-Speed TC Bur	20	18.4	15	26
Low-Speed TC Bur	20	25	17	41
Stainbuster Bur	20	48.2	42	66

(Table 3). Ra and Rz values revealed significant differences between these removal methods (p<0.001). According to the Rq values, the high-speed tungsten carbide bur and stainbuster bur groups produced significantly different results. There was no significant difference between low-speed tungsten carbide bur groups.

In this study, the results demonstrated that the degree of enamel damage was minimal with the stainbuster bur in all parameters (Ra, Rz, and Rq). The degree of enamel damage was maximal with the high-speed tungsten carbide bur in all parameters (Ra, Rz, and Rq).

DISCUSSION

Several clean-up methods are used after debonding to remove fixed appliances from the enamel surface. In any method, some damage occurs on the enamel surface after bracket debonding and resin removal.[15] Many authors have declared that the extent of this damage largely depends on the bracket material and the debonding technique.[20-23] The formed damage reduces the resistance of the enamel and increases the risk for dental caries.[24] In this study, we compared mean value changes on the enamel surface roughness after debonding with various burs at pretreatment and posttreatment. Instead, of comparing applied burs with a control group without intervention, surface roughnesses of the same teeth were evaluated at pretreatment and posttreatment. Thus, this ensured that the surface damage was created by the removal technique or was already present before the bonding procedure.[25]

Studies conducted to date have indicated that Ra suffers some faults as it cannot diversify between heights or valleys or between grooves with shallow or deep lengths.[9, 26, 27] To better identify irregularities on the enamel surface, other roughness parameters must be evaluated. In this study, we compared changes of enamel surface roughness mean values after debonding in all parameters (Ra, Rq, and Rz).

In the present study, there were significant differences in the measurements of surface roughness between the groups made before bonding on sound enamel. There were higher values with the use of the carbide bur groups than in the stainbuster bur group in Ra, Rq, and Rz parameters (p<0.001). These differences between surface roughnesses were obtained in accordance to the profilometer measurements. Also, all applied finishing burs changed the surface structure. The degree of enamel damage was minimal with the stainbuster bur in all parameters (Ra, Rz, and Rq) while it was maximal with the high-speed tungsten carbide bur in all parameters (Ra, Rz, and Rq).

Studies evaluating enamel surface roughness after various type of finishing procedures have been published. Ahrari et al.[2] evaluated enamel surface changes with different techniques: a low-speed tungsten carbide bur, a high-speed tungsten carbide bur, an ultrafine diamond bur, and using a Er:YAG laser. They compared results with a profilometer. According to their results, surface roughness increased after the use of high-speed tungsten carbide, diamond burs, or the Er:YAG laser with irreversible enamel damage. Unlike our study, their results showed that

Table 3. Descriptive statistics and the results of ANOVA and Tukey's HSD test

Groups	n	Mean±SD	Min	Max	p	Post-hoc Tukey
Ra						
High-Speed TC Bur	20	1.81±0.24	1.56	2.10	0.000	A
Low-Speed TC Bur	20	1.07±0.18	0.86	1.31		B
Stainbuster Bur	20	0.52±0.14	0.38	0.80		C
Rq						
High-Speed TC Bur	20	0.99±0.23	0.72	1.30	0.021	A
Low-Speed TC Bur	20	0.55±0.19	0.38	1.02		AB
Stainbuster Bur	20	0.39±0.16	0.15	0.57		B
Rz						
High-Speed TC Bur	20	1.58±0.28	1.38	1.94	0.001	A
Low-Speed TC Bur	20	1.08±0.22	0.81	1.43		B
Stainbuster Bur	20	0.47±0.23	0.24	0.80		C

Ra: average surface roughness; Rq: root mean square roughness; Rz: average roughness depth; SD: standard deviation

there was no significant difference between the different treatment stages, in terms of surface irregularities, when the low-speed tungsten carbide bur was used. Furthermore, they found it to be the safest technique. Karan et al.[17] compared the surface roughness with a tungsten carbide and a fiber-reinforced composite bur. They evaluated results with AFM and reported that both burs affected the enamel surface and the composite bur eliminated surface roughness while the tungsten carbide bur increased enamel roughness. Similar our study, using tungsten carbide burs increased the surface roughness.

Trakyali et al.[28] reported that clean-up performed only using tungsten carbide burs may lead to increased enamel surface roughness. Polishing with a stainbuster bur eliminated enamel surface roughness that may develop the light reflection of enamel. In our study, we used a stainbuster bur to remove resin and our profilometer results showed that the stainbuster bur increased surface roughness, albeit less than the tungsten carbide bur.

In the present study, comparison of different types of finishing methods showed that application of the stainbuster bur, low-speed tungsten carbide bur, or high-speed tungsten carbide bur all produced irregularities on the enamel surface and that there were statistically significant differences among the groups. The study results implied that the application of a stainbuster bur is the safest method regarding the damage caused to the enamel surface. The degree of irreversible enamel damage is minimal when using a stainbuster bur while adhesive removal with a low-speed tungsten carbide bur, and especially by a high-speed tungsten carbide bur, can cause a significant and irreversible increase in enamel surface irregularities. Finishing procedures with tungsten carbide burs may result in the removal of tooth substances from surface. So, in agreement with Ryf et al.,[29] the loss of enamel is unavoidable while effectively cleaning the enamel surface after debonding.

In this study, performed under laboratory conditions, it is impossible to recreate the oral environment. Also, in vitro bond strength testing is not fully reflective of intra-oral conditions. However, by using many samples and showing the parametric distribution of data, this standardized testing procedure was used in an attempt to create a laboratory technique that was as representative of the clinical situation as possible. Another limitation of this study was that the surface roughness was evaluated only by profilometer for its cost and accessibility. Future research to compare surface roughness with more measurements and evaluations should be performed.

CONCLUSION

The three types of burs used for finishing methods revealed significant differences in the enamel surface after debonding. The stainbuster bur created smoother surfaces than the other applied methods.

Further research and new techniques are required for finishing methods without damaging the enamel surface.

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