

Evaluation of enamel roughness after ceramic bracket debonding and clean-up with different methods

Geraldo de Silveira Albuquerque¹, Mário Vedovello Filho², Adriana Simoni Lucato²
Eloísa Marcantonio Boeck², Viviane Degan², Mayury Kuramae²

¹DDS, MS in Orthodontics, Department of Orthodontics, University Fundação Hermínio Ometto, UNIARARAS, Brazil

²DDS, MS, PhD, Professor, Department of Orthodontics, University Fundação Hermínio Ometto, UNIARARAS, Brazil

Abstract

Aim: This study evaluated the surface roughness (Ra) and the topography (scanning electron microscopy) of the dental enamel after use of different methods for removal of residual resin after debonding of orthodontic brackets. **Methods:** Nine roughness measurements in three directions were made on enamel surface of 60 human premolars before bracket bonding (Ra initial). Ceramic brackets were bonded with Transbond XT and stored for 24 h/37°C before debonding with pliers. The specimens were divided in five groups according to the method used for removal of residual resin: control (C); carbide bur at slow-speed (CL); carbide bur at high speed (CH); Shofu tip at low speed (SB); Shofu tip at high speed (HB); debonding pliers (ZP). Nine final surface roughness measurements (Ra final) were made and one specimen of each group was observed by SEM. The data were analyzed statistically by ANOVA, Tukey's test and paired t test ($p < .05$). **Results:** Ra final of SB was significantly higher than C, CL, CH, and ZP groups. The t-test showed that the Ra final was significantly higher than Ra initial for SB and CL. **Conclusions:** The method used for removal of residual resin influenced the roughness of the enamel. Carbide bur at high speed presented the best results and Shofu at low speed presented the worst results.

Keywords: Orthodontics. Dental debonding. Orthodontic brackets.

Introduction

Direct bonding techniques using orthodontic brackets on enamel is possible due to mechanical interaction between restorative material and enamel surface. Acid etching of enamel creates a micro-retentive surface and allows for the mechanical woven between enamel and resin materials¹. In addition, the adhesive technique recommended by Newman² enabled the improvement of the orthodontic apparatus, resulting in a more effective bonding between enamel and brackets.

Bracket bonding has many benefits for the orthodontic treatment, such as reduction of the risk of caries and periodontal diseases, simplification of the technique, oral hygiene most adequate, and reduction of the esthetic discomfort³. Due to the improvement of the bonding materials and techniques, bracket bonding is not a great operational obstacle currently. However, problems concerning to removal of the residual adhesive persist and damages on enamel surface can be created⁴. Gwinnet and Cens⁵ reported that the existence of small portions of unfilled resin remnant does not predisposes to the accumulation of plaque and wear occurs over time. However, this does apply to filled resins because a good part of them has high resistance to wear and biofilm accumulates more easily, making it difficult the cleaning of these areas⁴.

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Correspondence to:

Mário Vedovello Filho
a/c Pós-Graduação – Mestrado em Ortodontia
Av. Maximiliano Baruto, 500 - Jd. Universitário
CEP: 13607-339 - Araras -SP
E-mail: vedovelloorto@terra.com.br

Concern about the integrity of the dental enamel dates back to the development of enamel etching, and its use in bonding of orthodontic brackets⁶. However, there is little discussion among orthodontists about the amount of enamel lost during the bonding and debonding of brackets. The aims of debonding of brackets are to remove the accessories and all the resin attached to teeth, and restore the enamel surface as close as possible to pretreatment condition, without inducing iatrogenic damages.

Several methods and techniques have been proposed to eliminate resin remnants. Ideally, the removal takes place so that the original surface remains smooth and the qualities of the enamel are preserved intact as close as possible to its original appearance. The fact that resins usually have similar color to that of enamel, especially when the tooth is wet, is an additional difficulty even when mechanical devices are employed⁷.

There are several methods used for removal of residual resin after debonding of orthodontic brackets: sandblasting with aluminum oxide, carbide burs at high and low speed, debonding pliers, and abrasive wheels⁸. Although orthodontic research has focused on the development of new techniques of brackets bonding, the problems arising from bracket debonding and removal of residual resin from enamel have not received the same attention. Orthodontists do not have special care with possible changes in enamel during the removal of residual resin. However, damages on enamel are irreversible, and should be avoided in order to reduce the unnecessary removal of sound tissues. The aim of this study was to evaluate the surface roughness (Ra) and the topography (scanning electron microscopy) of the dental enamel after use of different methods for removal residual resin after debonding of orthodontic brackets.

Material and methods

Sixty freshly extracted human maxillary premolars with intact buccal enamel were collected and stored in a solution of 0.2% (weight/volume) thymol. The criteria for tooth selection included intact buccal enamel not subjected to any bracket bonding procedures, no damage caused by the extraction forceps, and no caries. The crowns were separated from root using diamond disks (KG Sorensen, Rio de Janeiro, RJ, Brazil) and embedded in acrylic resin (Vipi flash, Pirassununga, SP, Brazil) with the buccal surface exposed. After mounting, the teeth were cleaned and polished with pumice and rubber prophylactic cups for 10 s. Surface roughness (Ra) was measured using a surface roughness-measuring device (Surfcord model 170, Japan). For each specimen, nine measurements in three different directions were made with a cutoff value of 0.8 mm. The measurements were made before (Ra Initial) and after (Ra Final) the adhesive remnant removal. Roughness variation was obtained with the equation $Ra_{\Delta} = Ra_{\text{final}} - Ra_{\text{initial}}$. After the initial roughness measurements, 10 specimens were stored in distilled water until the final roughness measurements and the other specimens were subjected to bracket bonding procedure.

The bonding area was delimited using an adhesive tape (3M, Nova Odessa, SP, Brazil) positioned at the center

of the buccal surface. The teeth were acid etched with phosphoric acid 37% (Scotchbond 3M/ESPE, St. Paul, MN, USA) for 20 s, washed and dried for 10 s. The Transbond XT Primer (3M Unitek, Monrovia, CA, USA) was applied on the enamel surface and dried lightly with compressed air for 10 s. The resin composite Transbond XT (3M Unitek) was applied on the bottom of the ceramic brackets (Henry Schein INC., Melville, NY, USA), positioned and fixed on teeth with manually pressure to extrude the excess material. The photoactivation was performed with halogen lamp (XL2500, 3M) for 40 s and the specimens were stored in distilled water for 24 h at 37°C before debonding. The brackets were removed using bracket-removing pliers (ICE-Mocar 346) and the remnant adhesive was checked under a stereomicroscope at 40X (Carl Zeiss, Manaus, AM, Brazil) to certify that all adhesive was present on enamel.

The specimens were divided in 5 groups (n=10) according to the method of removal of the remnant resin: 32-fluted tungsten carbide bur at slow-speed handpiece (CL); 32-fluted tungsten carbide bur at high-speed handpiece (CH); Aluminum oxide tip Shofu at low-speed hand-piece (SB); Aluminum oxide tip Shofu at high-speed handpiece (HB); Zatty 934 debonding pliers (ZP) (Figure 1). The specimen surface was checked with a probe to certify that all remnant resin was removed. Nine final surface roughness measurements in different directions were made for each specimen at the same sites of initial measurements.

One representative specimen of each group was observed with a scanning electron microscope (model Jeol JSM 5600 LV, Tokyo, Japan) to illustrate the effect of different methods of adhesive removal on enamel topography.

The data were subjected to analysis of variance (ANOVA) and Tukey's post-hoc test to compare the influence of different methods to remove the residual resin on enamel roughness. The paired t test was used to analyze the difference in surface roughness before (baseline) and after the adhesive removal. A level of significance of 5% was used for all analyses.

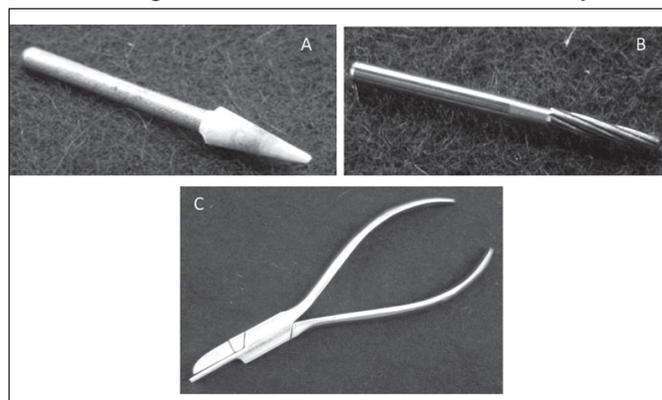


Fig. 1. Materials used to remove the resin remnant. A – Shofu tip; B – tungsten carbide bur; C – Zatty 934 pliers.

Results

The mean roughness values are presented in Table 1. The ANOVA showed that the method to remove the residual resin influenced significantly the roughness of the enamel

Table 1. Surface roughness (Ra) (standard deviation) of enamel before bracket bonding and after removal the residual adhesive using different methods.

Methods	Roughness values (μm) (SD)					
	Ra initial		Ra final		Ra delta	
Control	0.42 (0.06)	a, A	0.33 (0.10)	c, A	-0.1	b
Debonding pliers	0.49 (0.12)	a, A	0.72 (0.44)	bc, A	0.24	b
Shofu at high speed	0.57 (0.10)	a, A	0.72 (0.27)	ab, A	0.16	b
Shofu at low speed	0.48 (0.14)	a, B	1.19 (0.30)	a, A	0.72	a
Carbide bur at high speed	0.47 (0.11)	a, A	0.62 (0.29)	bc, A	0.15	b
Carbide bur at low speed	0.48 (0.14)	a, B	0.65 (0.19)	bc, A	0.17	b

Lowercase letters in the columns and uppercase letters in the rows indicate statistically significant difference ($p < 0.05$).

($p < 0.001$). The Shofu tip at low speed promoted the highest surface roughness on enamel compared to debonding pliers, carbide bur at high speed, carbide bur at low speed and control group ($p < 0.05$). However, there was no significant difference between Shofu at low and high speeds ($p > 0.05$). Carbide bur at low speed, Carbide bur at high speed and debonding pliers showed no significant difference compared to control group ($p > 0.05$).

The difference between the Ra final and Ra initial was calculated and described as Ra delta. The results showed that Shofu at low speed presented the highest Ra delta, significantly higher ($p < 0.05$) than the others methods, which showed no significant differences ($p > 0.05$) among them (Table 1).

Discussion

The development of dental materials, mainly resin composite and adhesive systems, has led to a more effective adhesion between enamel and resin, reducing bracket bonding failure rate during orthodontic treatment. However, due to the increased adhesion to enamel, removing the residual resin after bracket debonding became more difficult. Residual resin remains in enamel after debonding, or depending on the method of debonding used, cracks can be produced on enamel. Therefore, the method of removal of the residual resin is very important to avoid damages on enamel, such as cracks, increased roughness of enamel, excessive enamel wear⁹, overheating of the tooth and pulp necrosis¹⁰.

The results of this study showed that the enamel roughness after the clean-up with Shofu at low speed was significantly higher than the other methods ($p < .05$). Besides, t-test showed that the Ra final was significantly higher than Ra initial when the clean-up was performed with Shofu and tungsten carbide bur at low speed ($p < .05$). Shofu and tungsten carbide bur at low speed showed not be appropriate to remove the residual resin due to higher irregularity of the enamel after use of these methods. Due to the scratches that the Shofu tip generates on the enamel surface, it is indicated only for gross removal of the residual resin. Retief and Denys¹¹ reported that tungsten carbide burs are most efficient for resin removal. However, carbide burs are harder than enamel¹² and, when used at high speed, can damage the underlying enamel¹²⁻¹³. Zachrisson and Artun¹⁴ recommended using carbide burs but at low speeds. Zarrinnia et al.¹⁵ recommended the removal of the bulk of the remaining resin with a 12-fluted tungsten carbide finishing bur (TCB), operated at high

speed (above 200,000 rpm) with adequate air cooling. All these investigations were carried out to evaluate the effects of different clean-up techniques on enamel surface.

The literature is controversy about the most effective method of removal the residual resin. Van Waes et al.⁶ and Zachrisson and Artun¹⁴ concluded that a TCB at low speed produced the finest scratch pattern with the least enamel loss of 7.4 μm . Retief and Denys¹¹ recommended the use of TCB at high speed with adequate air cooling, whereas Rouleau et al.¹³ and Campbell¹⁶ suggested water spray instead of air cooling for heating control.

In clinical settings, cooling procedures that use air-water sprays are essential to ensure the prevention of pulpal damage. Removal of resin remnants with a tungsten carbide bur using a high-speed handpiece without water cooling produced temperature increases exceeding the critical 5.58°C value for pulpal health. Clean-up with water cooling never produced temperature changes exceeding the critical value¹⁰. It was related that the number of blades affects the wear of resin composite and the heating during the removal of resin remnants from enamel surface. Temperature rise of 9.4°C was found using a 6-fluted bur, followed by the 12-fluted bur (6.5°C) and 1.2°C using a 40-fluted bur. The removal of residual adhesive after debonding is best performed with fine burs¹⁷.

Removal of unfilled resin remnants with hand instruments results in a mean enamel loss of 7.7 μm . Rotary instruments, however, are required for cleaning up filled resin and the enamel lost for high-speed bur and low-speed bur was respectively 19.2 μm and 11.3 μm ¹⁸. The enamel loss after the use of the high-speed tungsten carbide bur was greater compared to low speed. The least enamel loss occurred after the use of the slow-speed tungsten carbide bur or the debonding pliers. However, more residual adhesive are associated with the use of the debonding pliers⁹.

The removal of residual resin with rotary instruments in low speed produces more vibration and generates discomfort for patients. Although the enamel surfaces after treatment with the low-speed hand piece was irregular, the natural enamel also was slightly repetitive and spiky over the whole enamel surface area¹⁹. However, resin remnant removal with low-speed instruments has disadvantages for pulpal health and patient comfort¹⁹.

Another disadvantage of removal of residual resin with rotary instruments is the generation of aerosols. It has been found that the potentially hazardous action of adhesive particulate aerosol produced by grinding, composite resin

particulates may act as endocrinological disruptors²⁰.

These results suggest the pliers as an appropriate method for removal of residual resin, since it produced little roughness of enamel. These results are in agreement with Hossein et al.⁹, who found good results using the pliers, but are in disagreement with the findings of other studies^{13,21}, which considered this method undesirable due to the higher occurrence of deep grooves in enamel produced by the removal of the residual resin. Furthermore, some portions of the resin remains on the enamel after clean-up when pliers are used (Figure 2).

In this study, SEM was used to give a better understanding of what happens to enamel with the different methods of

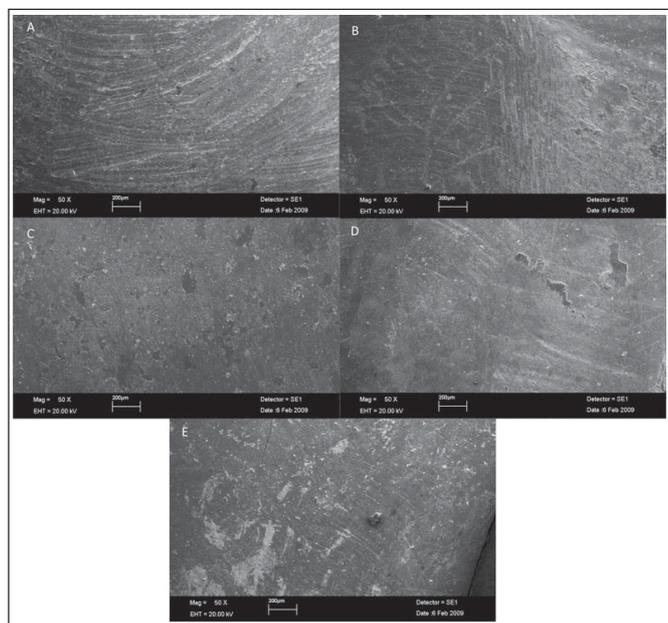


Fig. 2. Representative SEM micrographs of enamel surfaces at 50x magnification after cleaning clean-up of enamel with: A-tungsten carbide bur at high speed; B - tungsten carbide bur at low speed; C - Shofu tip at high speed; D - Shofu tip at low speed; E - Zatty 934 pliers.

resin removal tested. Nonetheless, SEM lacks a quantitative scale, cannot be used for the comparative assessment, and provides only subjective information²².

TCB, Shofu and pliers promoted the lowest roughness on the enamel in the present study. SEM micrographs clearly demonstrate that enamel scarring was inevitable with both low and high-speed TCB and Shofu (Figure 2). Using pliers, TCB and Shofu tip with high speed seems to be very efficient ways to clean the surface and the least time consuming. The TCB and Shofu with low speed were the most hazardous procedure to the dental enamel. However, the SEM and surface roughness methods cannot measure the quantitative loss of enamel during clean-up procedures. Therefore, when TCB or Shofu are used at high speed, damages and excessive wear of enamel may occur due to difficulty of distinguishing the resin from enamel and controlling its wear¹³.

The findings of this study showed that no method of removal the residual resin was able to leave the enamel surface with roughness similar to that of intact enamel. Therefore, after removing the resin remnants from enamel surface following bracket debonding, polishing of tooth surface is recommended

to minimize the grooves and irregularities left by the method used for resin removal and reduce the surface roughness.

Based on the methodology and analysis of results it was concluded that: 1. The method of removal the residual resin influenced the roughness of the enamel; 2. The best enamel roughness results were found with tungsten carbide bur at high speed and the worst results were obtained with Shofu tip at low speed; 3. SEM showed that no method eliminated all the irregularities left after the bonding/debonding of brackets.

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