Evaluation of enamel surface after bracket debonding and adhesive removal with six different methods

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INTRODUCTION

The main goal of orthodontic treatment in general is to achieve stability of occlusion and to improve dentofacial aesthetics. The primary concern is to ensure that no permanent damage on the tooth enamel surface has occurred after the completion of multibracket appliance treatment. The optimal method of brackets debonding depends on the type of brackets used in a therapy [1]. Following this procedure, it is necessary to remove any remaining resin from the teeth, which can often cause enamel surface irregularities. The amount of enamel loss may be determined by clinicians’ manual abilities and instruments used in clean-up procedures [2, 3]. Resin remnants on the tooth surface could cause enamel discoloration and dental plaque accumulation. Some studies show that the type of adhesive systems and resin removal procedures are responsible even for tooth color changes [4]. Previous studies refer to a variety of instruments that can be used for adhesive removal after brackets debonding. Rotary instruments (diamond, carbide burs, and abrasive discs), hand instruments (pliers and scalers), and ultrasonic scalers are among the most widely used [5–10]. An optimal procedure for adhesive removal that leaves no damage to the enamel surface has not been accepted yet [5]. Recently, in some studies, lasers and sandblasting have been considered as alternative methods for removing the remaining adhesive [11, 12]. Several studies conclude that carbide burs cause less damage to the enamel if compared to fine diamond burs, while still causing greater damage than the composite burs [13, 14]. The visual assessment of the enamel surface is often performed to evaluate and define a type of damage occurred during the adhesive removal procedures [15–18].

Multi-step systems, including fine and superfine tungsten carbide burs or abrasive disks, are commonly applied as part of the adhesive removal procedures followed by different types of polishers for smoothing the enamel surface [19]. These procedures leave no scratches on the enamel surface, even if they have been caused by tungsten carbide burs or abrasive discs. The previous studies focused mostly on different methods for adhesive removal, including the polishers.
The purpose of the in vitro study was to examine the enamel surface, after the application of six different methods for adhesive removal following brackets debonding procedure, as well as to compare their effects on enamel surface topography and the time required for adhesive removal.

METHODS

This study has been approved by the local Institutional Review Board (protocol number 01-2127-10/15). A total of 245 human premolars were extracted for the purpose of orthodontic treatment and consequently appropriately prepared and stored in 0.9% NaCl containing 0.1% thymol according to ISO TS 11405:2015, for no longer than three months [20]. All the teeth specimens were examined with a 10 × magnifying lens (Olympus, SZX 9, Tokyo, Japan) in order to assess whether the collected samples fulfilled the major criteria: an intact oral and buccal surface without visible damages, carious lesions and chemical exposures. Out of the 245 specimens being surveyed, 35 served as an untreated control group [21]. Subsequently, the middle third of the buccal surfaces of 210 premolars was etched for 20 seconds with 38% phosphoric acid (OC Orthodontics, McMinnville, OR, USA). After they had been rinsed with water for 30 seconds and air dried to frosty-white appearance, the buccal surfaces of the teeth were treated with the Aspire primer 7GM (OC Orthodontics) and light-cured for 10 seconds with a LED curing unit (Woodpecker, Guilin, China). Mesh pads of metal brackets Ortho Organizer Elite OptiMIM (Henry Schein® Orthodontics, Carlsbad, CA, USA) were removed by a dull round end tapered multi-fluted tungsten carbide bur at high speed to determine the mode of bond failure at the bracket base-adhesive interface, allowing the complete amount of resin to be left on the enamel surface of all 210 teeth [22]. A small amount of Aspire resin 5GM (OC Orthodontics) was put on the bases of metal brackets. The brackets were then pressed firmly onto the prepared enamel surface to extrude the excess of composite material around them, which was removed with a tip of the probe. A light curing procedure was performed for 40 seconds according to the manufacturer’s instructions [21]. All the samples were left in the artificial saliva for 48 hours, allowing complete polymerization of the adhesive as reported in similar studies [3, 22]. The brackets were debonded using debonding Ixion pliers (DB Orthodontics, Silsden, UK). Furthermore, the teeth samples were divided into six groups (35 teeth in each group), depending on the method used for remaining adhesive removal: Group A – a 12-fluted round end tapered fissure tungsten carbide bur (DB Orthodontics) at 32,000 rpm, Group B – a 12-fluted round tungsten carbide bur (H1SE 204031, Komet Dental, Lemgo, Germany) at 8,000 rpm, Group C – a composite bur (Stainbuster Jumbo, DB Orthodontics) at 40,000 rpm, Group D – an abrasive disc (sand medium abrasive disc, E.C. Moore Co., Dearborn, MI, USA) at 16,000 rpm, Group E – adhesive removing pliers (DB Orthodontics), Group F – an ultrasonic scaler (Sirosonic L scaler, Sirona Dental Systems, Long Island city, NY, USA) (Figure 1). All bonding, debonding and clean-up procedures were carried out by the same operator to eliminate differences among operator’s techniques [23]. Adhesive removal from the enamel surface after every third teeth in the study was performed with a new bur for rotary instruments in Groups A, B, C, and D, respectively [22]. The adhesive removal procedure duration was measured in seconds. Residual adhesive removal was fully verified under a dental chair operating light by the operator. The sample was prepared for scanning electron microscopy (JSM 6460 LV, JEOL Ltd., Tokyo, Japan), including a control group. For each specimen, four images were obtained (15 ×, 100 ×, 500 ×, 1,500 × magnification) (Figure 2). The evaluation of
enamel surface was performed by SEM, the enamel surface index (ESI) system being used in the process. ESI was introduced by Zachrisson and Arthun, and estimated as in the following [16]:

Score 0 – Regular enamel surface without scratches; Visible intact perikymata;
Score 1 – Satisfactory enamel surface; Minor scratches and some healthy enamel;
Score 2 – Acceptable enamel surface, several deep scratches; Absent perikymata;
Score 3 – Defective enamel surface with several deep and course scratches and no perikymata;
Score 4 – Unacceptable enamel surface with very coarse, deep scratches, healthy enamel absent [16, 17].

It is fundamental to note that ESI evaluation was performed by an examiner who had no previous knowledge of the specific group the specimens belonged to, after one and after two weeks for each specimen. In case of any discrepancy, the third assessment determined the final score [17].

**Statistical analysis**

The statistical package IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp. Armonk, NY, USA) and Microsoft Excel 2010 (Windows, Redmond, WA, USA) were used for data analysis. Descriptive results of ESI scores were calculated and expressed as frequencies, percentages, mean values, and standard deviations. The significant differences of the mean values of ESI scores and the duration of all six methods were determined by ANOVA with the F-value and the Fisher’s test as well as by Tukey’s post hoc test.

The results for ESI scores are shown in Table 1. For Groups A (tapered fissure tungsten carbide bur), C (composite bur) and D (abrasive disc), the ESI score 1 was predominant. The highest incidence of ESI score 2 was observed in Groups E (adhesive removing pliers) and F (ultrasonic scaler). The ESI score 3 was the most frequent in Group B (round tungsten carbide bur) and the ESI score 0 was found only in 35 premolars that served as a control group.

**DISCUSSION**

From the results, it is clear that adhesive removal after brackets debonding has a great influence on enamel surface topography [24, 25]. Therefore, clinicians should apply an appropriate adhesive removal procedure, accepting the fact that minor damage to the enamel is inevitable.

Methods used in the process of adhesive removal coincide with the required protocol used in similar studies [26, 27]. The visual assessment of enamel surface

**RESULTS**

The results for ESI scores are shown in Table 1. For Groups A (tapered fissure tungsten carbide bur), C (composite bur) and D (abrasive disc), the ESI score 1 was predominant. The highest incidence of ESI score 2 was observed in Groups E (adhesive removing pliers) and F (ultrasonic scaler). The ESI score 3 was the most frequent in Group B (round tungsten carbide bur) and the ESI score 0 was found only in 35 premolars that served as a control group.

The lowest average value of ESI scores (1.08) was determined in Group C (composite bur), while the highest average value of ESI scores was determined in Group F (ultrasonic scaler, 2.42). The one-way ANOVA test showed statistically significant differences among the ESI scores of all six methods (F (5,204) = 24.53, p < 0.01) (Table 1). A post-hoc analysis (Tukey’s post-hoc test) established different levels of statistically significant differences of ESI scores within the groups (Table 2). The mean values of ESI scores in Groups C (composite bur) and D (abrasive disc) showed a statistically significant difference compared to Groups B (round tungsten carbide bur), E (adhesive removing pliers), and F (ultrasonic scaler).

However, the most time-consuming method for adhesive removal was the application of the composite bur. It is significant to note that using the abrasive disc in the adhesive removal procedure was proved the least time-consuming method (Table 3 and 4).

**Table 1. Distribution of enamel surface index (ESI) scores for six different adhesive removal methods**

| Method for adhesive removal (J) | ESI score | Mean ± Standard Deviation | ANOVA |
|--------------------------------|-----------|---------------------------|-------|
|                                | 0 | 1 | 2 | 3 | 4 | df** | F test | p |
| Fissure TCB*                   | 0 | 22 | 13 | 0 | 0 | 1.37 ± 0.49 | 5 | 24.53 | 0.001 |
| Round TCB*                    | 0 | 0 | 10 | 24 | 1 | 1.94 ± 0.93 | 5 | 24.53 | 0.001 |
| Composite bur                  | 0 | 32 | 3 | 0 | 0 | 1.08 ± 0.28 | 5 | 24.53 | 0.001 |
| Abrasive disc                  | 0 | 29 | 6 | 0 | 0 | 1.17 ± 0.38 | 5 | 24.53 | 0.001 |
| Pliers                        | 0 | 7 | 26 | 1 | 1 | 1.88 ± 0.58 | 5 | 24.53 | 0.001 |
| Ultrasonic scaler             | 0 | 0 | 15 | 13 | 3 | 2.42 ± 0.81 | 5 | 24.53 | 0.001 |
| Control group                 | 35 | 0 | 0 | 0 | 0 | 1.08 ± 0.28 | 5 | 24.53 | 0.001 |

* tungsten carbide bur; ** degrees of freedom

**Table 2. Post-hoc analysis of significant differences in mean values of enamel surface index (ESI) scores for all six methods**

| Method for adhesive removal (J) | Fissure tungsten carbide bur | Round tungsten carbide bur | Composite bur | Abrasive disc | Adhesive removing pliers | Ultrasonic scaler |
|--------------------------------|-----------------------------|---------------------------|---------------|--------------|--------------------------|------------------|
|                                | M (I–J) p | M (I–J) p | M (I–J) p | M (I–J) p | M (I–J) p | M (I–J) p | M (I–J) p | M (I–J) p |
| Fissure tungsten carbide bur   | . . | -0.57* | 0.002 | -0.28* | 0.399 | 0.2 | 0.764 | -0.51* | 0.009 | -1.05* | 0.001 |
| Round tungsten carbide bur     | 0.57* | 0.002 | . . | 0.85* | 0.001 | 0.77* | 0.001 | 0.05 | 0.999 | -0.48** | 0.017 |
| Composite bur                  | -0.28 | 0.399 | -0.85* | 0.001 | . . | -0.08 | 0.993 | -0.80* | 0.001 | -1.34* | 0.001 |
| Abrasive disc                  | -0.2 | 0.764 | -0.77* | 0.001 | 0.08 | 0.993 | 0.001 | . . | -0.71* | 0.001 | -1.24* | 0.001 |
| Adhesive removing pliers       | 0.51* | 0.009 | -0.1 | 0.999 | 0.80* | 0.001 | 0.71* | 0.001 | . . | -0.54* | 0.005 |
| Ultrasonic scaler              | 1.05* | 0.001 | 0.48** | 0.017 | 1.34* | 0.001 | 1.25* | 0.001 | 0.54* | 0.005 | . . |

* significant at p < 0.01; ** significant at p < 0.05
was performed by using ESI on SEM images, under four different magnifications for each specimen. Significant differences were found among different tested methods. The tapered fissure tungsten carbide bur, abrasive disc and composite bur caused less damage to the enamel in comparison to other three methods applied during the course of the study.

The operator’s control and proficiency in the use of the instruments for adhesive removal is another important factor to be considered in enamel surface evaluation [6, 8, 27, 28]. In the present study, two types of tungsten carbide burs have been applied: a 12-fluted end round tapered fissure tungsten carbide bur and a 12-fluted round tungsten carbide bur with reduced vibrations. As it had been assumed based on the study by Palmer et al. [22], the visual assessment confirmed more enamel damage caused by a round bur. However, using the SEM image evaluation in their study, Pignatta et al. [9] concluded that a tungsten carbide bur caused several scratches on the enamel surface, which were not observable after polishing.

Nevertheless, the results demonstrated only small irregularities on the enamel surface after removing adhesive remnants with a composite bur. This result is in line with those obtained by Karan et al. [13] and Erdur et al. [29] who reported that a composite bur provided a smoother enamel surface in comparison to a tungsten carbide bur. They emphasized that a composite bur decreased enamel surface roughness. Similarly, Cardoso et al. [27] reported that a composite bur and a Sof-Lex disc restored the enamel closely to its pre-treatment condition. The results obtained by the present study were based on the visual assessment allowing a comparison of all six methods. While some of the methods caused visible enamel damage (ultrasound scaler and round tungsten carbide bur), the other methods caused only minimal surface irregularities (composite bur, abrasive disc). An abrasive disc was less damaging to the enamel in comparison to a tungsten carbide bur, which is in accordance with the results obtained by Khatria et al. [30].

One of the concerns in orthodontic practice is also enamel loss during pumice prophylaxis, etching, debonding, and adhesive removal procedures. Even though this study is based only on the visual evaluation of SEM images, our results partly agree with the results reported by Hosein et al. [10] who used a quantitative method for enamel loss assessment. They concluded that significant enamel loss was caused by the use of a high-speed tungsten carbide bur and an ultrasonic scaler, while the use of a low-speed tungsten carbide bur and adhesive removing pliers caused only minor enamel loss.

Operating time for each method was measured in seconds. The duration of adhesive removal procedures can be influenced by different factors, including a method used for adhesive removal, a type and amount of residual adhesive and individual manual abilities of orthodontists [24]. The time required for residual adhesive removal with the composite bur, ultrasonic scaler, and adhesive-removing pliers was longer than time required for the application of other three methods (Table 3). Similarly, Karan et al. [13] and Erdur et al. [29] reported that the application of composite bur for adhesive removal required more time than the application of tungsten carbide bur. However, Eminkahyagil et al. [28] concluded that a high-speed tungsten carbide bur was the quickest method for adhesive removal in comparison to a low-speed tungsten carbide bur, a microetcher, and a Sof-Lex disc.

Although some methods were the most preserving to the enamel surface, they were also the most time-consuming. In clinical conditions, the use of polishing systems creates an aesthetically pleasant enamel surface after different adhesive removal methods. These systems also extend the duration of adhesive removal. Polishing systems were not applied in this study in order to achieve a clear and precise visual assessment of enamel surface after the use of all six methods. In addition, the efficacy of methods and their

**Table 3.** Descriptive statistics for the duration of adhesive removal procedures in seconds with the results of ANOVA with F value and Fisher test

| Adhesive removal method                  | n  | Mean (sec) ± Standard Deviation | df  | F test | p   |
|-----------------------------------------|----|---------------------------------|-----|--------|-----|
| Fissure tungsten carbide bur            | 35 | 29.17 ± 6.78                    |     | S      | 4.13| 0.001|
| Round tungsten carbide bur              | 35 | 25.51 ± 6.2                     |     |        |     |
| Composite bur                           | 35 | 30.93 ± 6.33                    |     |        |     |
| Abrasive disc                           | 35 | 17 ± 6.2                        |     |        |     |
| Adhesive removing pliers                | 35 | 24.31 ± 10.49                   |     |        |     |
| Ultrasonic scaler                       | 35 | 29.94 ± 10.99                   |     |        |     |

*degrees of freedom

**Table 4.** Post hoc analysis of significant differences in mean values of adhesive removal times for all six methods

| Time for adhesive removal (J) | Adhesive removal method | M (I–J) | p    | M (I–J) | p    | M (I–J) | p    | M (I–J) | p    | M (I–J) | p    |
|-----------------------------|-------------------------|---------|------|---------|------|---------|------|---------|------|---------|------|
| Fissure tungsten carbide bur | Operative time          | -3.65   | 0.91 | -5.41   | 0.662| 8.51    | 0.174| 1.2     | 0.999| -4.42   | 0.822|
| Round tungsten carbide bur   | Operative time          | 1.76    | 1.01 | 5.41    | 0.662|        |      | 13.93** | 0.002| 6.61    | 0.444|
| Composite bur                | Operative time          | -12.17* | 0.01| -8.51   | 0.174| -13.93**| 0.002| .       | .    | -7.31   | 0.328|
| Abrasive disc                | Operative time          | -4.85   | 0.76 | -1.2    | 0.999| -6.61   | 0.444| 7.31    | 0.328| .       | .    |
| Adhesive removing pliers     | Operative time          | 0.77    | 1.01 | 4.42    | 0.822| -0.98   | 1.00  | 12.94** | 0.005| 5.62    | 0.624|
| Ultrasonic scaler            | Operative time          |        |      |         |      |         |      |         |      |         |      |

*significant at p < 0.01; **significant at p < 0.05
influence on temperature changes of the pulp area and enamel loss should be considered in further studies in order to determine an optimal protocol for adhesive removal.

CONCLUSIONS

Significant enamel damage is found after the application of all six methods examined for adhesive removal following bracket debonding. Enamel surface examination confirms that minor enamel damage occurs after the use of a composite bur, followed by an abrasive disc and a tapered fissure tungsten carbide bur with a round end. The greatest damage to the enamel is determined after the application of an ultrasonic scaler followed by a round tungsten carbide bur and adhesive removing pliers.

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REFERENCES

1. Pithon MM, Santos Fonseca Figueiredo D, Oliveira DD, Coqueiro Rda S. What is the best method for debonding metallic brackets from patient’s perspective? Prog Orthod. 2015;16:1–6.
2. Bernardi S, Continenza MA, Macchiarelli G. Microscopic evaluation of the enamel surface after debonding procedures: An ex vivo study using scanning electron microscopy. Microscopie. 2018;29(11):7–14.
3. Al Shamsi AH, Cunningham JL, Lamey PJ, Lynch E. Three-dimensional measurement of residual adhesive and enamel loss on teeth after debonding of orthodontic brackets: An in-vitro study. Am J Orthod Dentofacial Orthop. 2007;131(3):301.e9–15.
4. Bocuny Y, Çehreli ZC, Polat-Özsoy Ö. Effect of different orthodontic adhesives and resin removal techniques on enamel color alteration. Angle Orthod. 2014;84(4):634–41.
5. Cochrane NJ, Ratneser S, Reynolds EC. Effect of different orthodontic adhesive removal techniques on sound, demineralized and remineralized enamel. Aus Dent J. 2012;57(3):365–72.
6. Stadler O, Dettwiler C, Meller C, Dalstra M, Verna C, Connert T. Application of a composite bur, an ultrasonic scaler, and a tapered fissure tungsten carbide bur with a round end was more time-consuming than the application of adhesive removing pliers, a round tungsten carbide bur, or an abrasive disc.

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Испитивање површине глеђи после уклањања бравица и адхезива помоћу шест различитих метода

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САЖЕТАК
Увод/Циљ Позадине уклањања ортодонтских бравица неопходно је уклонити остатак адхезива са површине зуба, што често узрокује оштећење глеђи. Циљ овог рада је био испитати површину глеђи после примене шест различитих метода за уклањање адхезива после уклањања бравица те упоредити трајање ове процедура.
Метод У овом истраживању прикупљено је 245 људских премолара, екстрахованих у ортодонтске сврхе. Металне бравице су постављене на 210 људских премолара применом адхезивног система Aspire. После одлепљивања бравица узорак је подељен на шест група према методи која се применила за уклањање адхезива: фисурно тунгстен-карбидно сврдло, округло тунгстен-карбидно сврдло, композитно сврдло, абразивни диск, клешта за уклањање адхезива и ултразвучни инструмент. Од укупно 245 премолара, 35 премолара је чинио контролну групу. Време уклањања адхезива је мерено за сваку од метода. Оштећење глеђи је процењено према индексу површине глеђи на микрографијама добијеним скенирајућом електронском микроскопијом.
Резултати Композитно сврдло је довело до најмањег оштећења глеђи (1,08). Примена абразивног диска је у краћем периоду довела до потпуног уклањања адхезива у односу на композитно сврдло (p < 0,01) и ултразвучни инструмент (p < 0,01).
Закључак Највеће оштећење површине глеђи је уочено послије уклањања адхезива помоћу абразивног диска. Ултразвучни инструмент је уочен као аутентичан метод за уклањање адхезива у 5 минута без уштећења глеђи.

Кључне речи: уклањање адхезива; оштећење глеђи; индекс површине глеђи