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Paper Accepted*

ISSN Online 2406-0895

Original Article / Оригинални рад

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

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

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Received: March 5, 2019
Revised: January 23, 2020
Accepted: January 28, 2020
Online First: January 31, 2020
DOI: https://doi.org/10.2298/SARH190305008A

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SUMMARY

Introduction/Objective After an orthodontic brackets debonding procedure it is necessary to remove any residual adhesive from the tooth surface, as this is a common cause of enamel damage. The aim of this study is to evaluate the enamel surface after the application of six different methods of adhesive removal following brackets debonding, as well as to compare the duration of these procedures.

Methods For the purpose of this study, 245 human premolars were extracted as part of the orthodontic treatment. Metal brackets were bonded to 210 human premolars with the Aspire adhesive system. After the debonding of brackets, the samples were divided into six groups according to the adhesive removal method applied: tapered fissure tungsten carbide bur, round tungsten carbide bur, composite bur, abrasive disc, adhesive removing pliers, and ultrasonic scaler. Out of 245 premolars, 35 served as a control group. The duration of adhesive removal was recorded. Enamel damages were estimated according to the enamel surface index on the scanning electron microscopy images.

Results Maximum preservation of the enamel surface was accomplished by using a composite bur (1.08). The application of abrasive disc was significantly less time-consuming in comparison to the application of a composite bur ($p < 0.01$) and an ultrasonic scaler ($p < 0.01$).

Conclusion The most harmful for the enamel surface was the use of an ultrasonic scaler as well as a round tungsten carbide bur. Adhesive removal done by an abrasive disc thus proved one of the least damaging and the least time-consuming methods.

Keywords: adhesive removal; enamel damage; enamel surface index

САЖЕТАК

Увод/Циљ Након уклањања ортодонтских бравица неопходно је уклонити остатак адхезива са површине зуба, што често узрокује оштећење глеђи. Циљ овог рада је био испитати површину глеђи након примене шест различитих метода за уклањање адхезива након уклањања бравица те упоредити трајање ових процедура.

Метод У овом истраживању прикупљено је 245 људских премолара, екстрахованих у ортодонтске сврхе. Металне бравице су постављене на 210 људских премолара применом *Aspire* адхезивног система. Након одлепљивања бравица, узорак је подељен на шест група према методи која се примењивала 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 чинило 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 временском периоду довела до уклањања адхезива у потпуности у односу на композитно сврдло (p < 0,01) и ултразвучни инструмент (p < 0,01).

Закључак Највеће оштећење површине глеђи је уочено након примене ултразвучног инструмента и округлог тунгстен карбидног сврдла. Уклањање адхезива помоћу абразивног диска се показало као метода која најбрже уклања преостали адхезив са зуба, а да при томе најмање оштећује глеђ.

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

INTRODUCTION

The main goals of orthodontic treatment in general are 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 [5–10] are among the most widely used. 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 3 months [20]. All the teeth specimens were examined with a 10x 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, USA). After they had been rinsed with water for 30 seconds and air dried to frosty-white appearance, the buccal surfaces of teeth were treated with the Aspire primer 7GM (OC Orthodontics, USA) and light-cured for 10 seconds with a LED curing unit (Woodpecker, China). Mesh pads of metal brackets (Ortho Organizer Elite OptiMIM, Henry Schein® Orthodontics, 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, USA) 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 pliers (Ixion pliers, DB Orthodontics, West Yorkshire, 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, West Yorkshire, UK) 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, West Yorkshire, UK) at 40,000 rpm, Group D – an abrasive disc (sand medium abrasive disc, E.C. Moore, Dearborn, Michigan) at 16,000 rpm, Group E – adhesive removing pliers (DB Orthodontics, West Yorkshire, UK), Group F – an ultrasonic scaler (Sirosonic L scaler, Sirona Dental Systems, NY, USA) (Figure 1). All bonding, debonding and clean-up procedures were carried out by the same operator (AA) 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, 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 Zachrison 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 (NN), who had no previous knowledge of the specific group the specimens belonged to, after one and after two weeks for each specimen. In a case of any discrepancy, the third assessment determined the final score [17].

Statistical analysis

The statistical package IBM SPSS Statistics 20 and Microsoft Excel 2010 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 test as well as by Tukey's post hoc test.

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, 4).

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 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.

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 round end 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 damages (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. 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 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 the minor damage to the enamel 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.

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.

ACKNOWLEDGEMENT

This paper is part of a research thesis on “The Evaluation of Enamel Surface After Removing Fixed Orthodontic Appliances” by Adriana Arbutina. The authors would like to thank Ivana Kitonjić and Jovana Milutinović for their assistance in translating this paper into English.

Conflict of interest: None declared.

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

Method for adhesive removal	ESI score					Mean ± Standard Deviation	ANOVA		
	0	1	2	3	4		*df***	*F test*	*p value*
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			
Composite bur	0	32	3	0	0	1.08 ± 0.28			
Abrasive disc	0	29	6	0	0	1.17 ± 0.38			
Pliers	0	7	26	1	1	1.88 ± 0.58			
Ultrasonic scaler	0	4	15	13	3	2.42 ± 0.81			
Control group	35	0	0	0	0				

*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	
Method for adhesive removal (I)	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	.	.	-0.71*	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 $p < 0.05$

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 value*
Fissure tungsten carbide bur	35	29.17 ± 6.78	5	4.13	0.001
Round tungsten carbide bur	35	25.51 ± 6.2			
Composite bur	35	30.93 ± 6.33			
Abrasive disc	35	17.00 ± 6.20			
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)	Fissure tungsten carbide bur		Round tungsten carbide bur		Composite bur		Abrasive disc		Adhesive removing pliers		Ultrasonic scaler	
Time for adhesive removal (I)	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	.	.	3.65	0.912	-1.76	0.997	12.17*	0.011	4.85	0.757	-0.77	1
Round tungsten carbide bur	-3.65	0.91	.	.	-5.41	0.662	8.51	0.174	1.2	0.999	-4.42	0.822
Composite bur	1.76	1	5.41	0.662	.	.	13.93**	0.002	6.61	0.444	0.98	1
Abrasive disc	-12.17*	0.01	-8.51	0.174	-13.93**	0.002	.	.	-7.31	0.328	-12.94**	0.005
Adhesive removing pliers	-4.85	0.76	-1.2	0.999	-6.61	0.444	7.31	0.328	.	.	-5.62	0.624
Ultrasonic scaler	0.77	1	4.42	0.822	-0.98	1	12.94**	0.005	5.62	0.624	.	.

* significant at $p < 0.01$;

** significant at $p < 0.05$

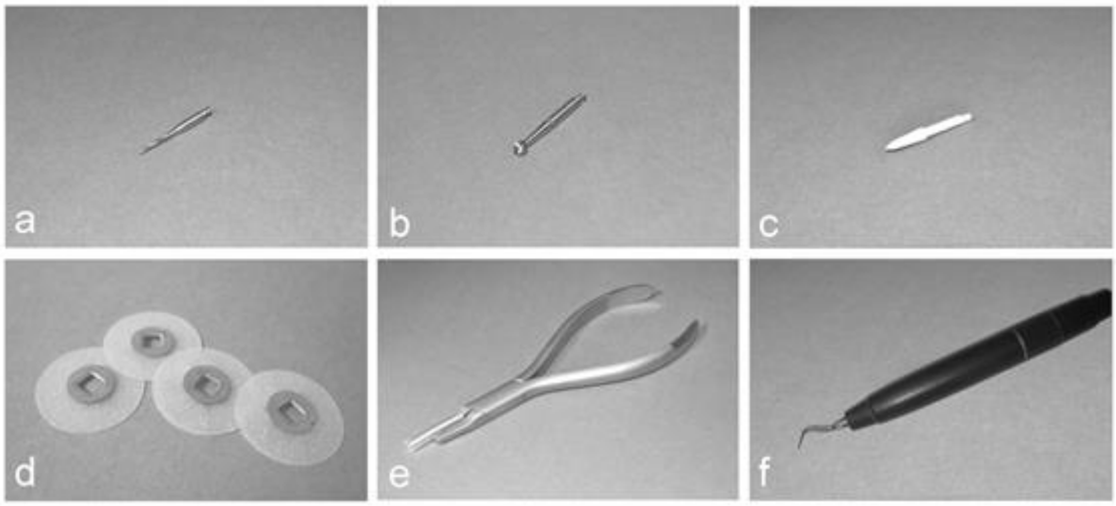

Figure 1. Methods for adhesive removal: a – tapered fissure tungsten carbide bur with a round end; b – round tungsten carbide bur; c – composite bur; d – abrasive discs; e – adhesive removing pliers; f – ultrasonic scaler

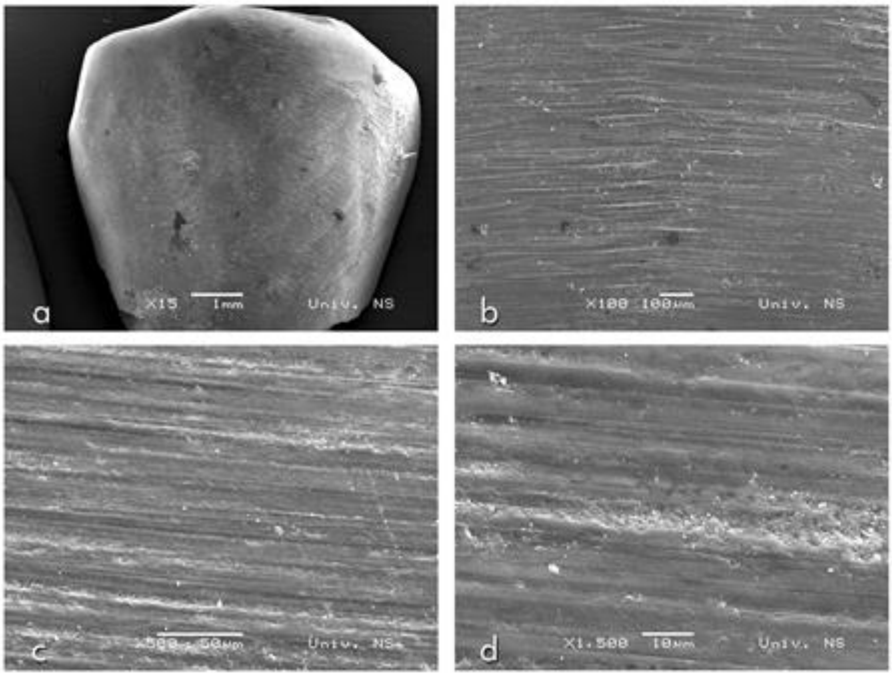

Figure 2. SEM images of enamel surface after residual adhesive removal with a twelve-fluted tapered fissure tungsten carbide bur with a round end: a – 15× magnification; b – 100× magnification; c – 500× magnification; d – 1,500× magnification