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Original research

Enamel surface roughness after orthodontic adhesive removal: an in vitro study comparing four clearance methods

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Purpose
Adhesive remnants removal is the last key step influencing orthodontic treatment outcomes. Four different clearance methods (CM) of orthodontic adhesive were evaluated to determine, which achieved the smoothest enamel surface in the shortest time.

Materials and Methods
75 intact premolars extracted for orthodontic purposes were included, sixty had an orthodontic bracket bonded and subsequently removed, and fifteen served as the control group. Four CMs were used to clear the tooth surface of 15 premolars each: carbide bur (CB), carbide bur with titanium nitride surface treatment + fine carbide bur (CBCB), glass fiber-reinforced composite instrument (GFCB), zirconia bur + glass fiber-reinforced composite bur (ZBCB). The processing time was recorded. In ten premolars from each group, the enamel surface was evaluated by atomic force microscopy estimating mean roughness (Ra), roughness profile value (Rq), and roughness depth (Rt). Enamel Damage Index (EDI) was assessed with a scanning electron microscope on 5 remaining premolars.

Results
Significant differences were observed in all evaluated parameters - Ra ($p<0.0001$), Rq ($p<0.0001$), and Rt ($p<0.0001$). GFCB exhibited the smoothest surface in all parameters. The lowest EDI exhibited teeth treated by GFCB, however, the differences were not significant. Working with GFCB took the longest time (mean 116 s), and the shortest with CBCB (mean 49 s).

Conclusion
Using CB is the fastest clearance method, but the enamel surface roughness was highest. Clearing with a set of instruments CBCB proved to be a fast method with satisfying remaining enamel roughness.

Keywords: *Enamel roughness, clearance method, orthodontics, adhesive, tooth surface*

Introduction

The goal of orthodontic treatment is to achieve treatment plan objectives efficiently while avoiding any iatrogenic damage. At the end of the active phase of the treatment, when removing fixed orthodontic appliances or attachments, the focus should be on preventing damage to hard dental tissues through the use of appropriate techniques and instruments during adhesive remnants removal. The roughness of the inadequately treated enamel surface might bring future problems, as the threshold roughness value of the enamel surface for bacterial adhesion has been determined as 0.2 µm (1). Conventional methods of adhesive removal can lead to macroscopically visible deep grooves ranging from 10 to 20 µm (1).

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In 1979, Zachrisson and Årtun evaluated the enamel surface after adhesive remnants removal using a scanning electron microscope (2). According to the degree of enamel damage, diamond tools were found to be unacceptable for adhesive remnants removal. Even fine diamond cutters caused coarse scratches. Using the fine diamond polishing discs led to an acceptable enamel surface but with deep scratches. Subsequently, a carbide bur (CB) was recommended as the best instrument for adhesive remnants removal (3-7). Further studies presented glass fiber reinforced composite instrument (GFCB) for adhesive remnants removal. It was originally designed to remove pigmentation and polish the enamel surface and established itself in orthodontics as a suitable tool for removing adhesive residues. Karan *et al.* (8) in 2010 in her study presented the effect of GFCB on an enamel surface - the achieved surface was smoother than compared with CB treatment. The same result was reached by Mohebi *et al.* (9); however, they identified the carbide CB as the tool of choice because of the shorter treatment time. In the present study two more CM methods were presented and compared to CB and GFCB, which are used in clinical practice, but were not compared to the effectivity of these two standard instruments.

The present study aimed to assess four CM used for the adhesive remnant removal in terms of the treatment duration for each CM and especially the resulting enamel surface roughness using atomic force microscopy and scanning electron microscopy. The null hypothesis of the study was that resulting enamel surface roughness and treatment time would not differ between the four CM.

Materials and Methods

Ethical approval

The survey was approved by the ethics committee of the Institutional Review Board EK/1/25/03/2021.

Experimental design

The material consisted of 75 intact premolars, all of which were extracted as part of an orthodontic extraction treatment plan. Each tooth crown was inspected for any visible cracks, scratches, or other damage on its buccal surface by visual inspection using dental light (A-dec 500 LED dental light) and a magnifying glass. Only intact and healthy teeth were included in the sample. The extracted teeth were randomly divided into five groups - 15 premolars in each.

To the buccal surface of sixty premolars metal premolar brackets Mini Master MBT (American Orthodontics, Sheboygan, WI, USA) were bonded in a standard manner. The brackets were positioned in the center of the vestibular surface of the anatomical crown according to the bracket placement rules. The prescribed bonding protocol was followed closely, every tooth surface was first etched for 30 seconds using 36% phosphoric acid (M+W Big Etch, M+W Dental, Büdingen, Germany), then rinsed with water for 30 seconds and dried with an air syringe. Subsequently, Transbond™ MIP adhesive (3M Unitek, St. Paul, MN, USA) was applied to the etched enamel surface, excesses were removed with a suction device. To ensure bond failure between the bracket and the adhesive layer during bracket removal, the bracket base was lubricated with a thin layer of petroleum jelly, allowing most of the adhesive to remain on the tooth surface (10). Then, Transbond™ PLUS Color Change Adhesive (3M Unitek, St. Paul, MN, USA) was applied to the bracket base, and the bracket was pressed onto the prepared enamel. The excess adhesive was removed with a probe, and each bracket was light-cured using a 3M ESPE Ortholux™ Luminous Curing light (3M Unitek, St. Paul, MN, USA) for 40 seconds (10 seconds each from the mesial, occlusal, distal, and gingival sides). The teeth with attached brackets were stored in water at room temperature for 24 hours. The following day, the brackets were removed by an experienced orthodontist using bracket-removing pliers (Dentaurum Premium Line 004-349, Dentaurum, Ispringen, Germany), following the "wing model" introduced by Brosh (11). The debonding pliers that were inserted under the occlusal and gingival wings of the bracket and pressed. As the bracket base was coated with petroleum jelly, minimal strength was necessary to debond the bracket. This method was proven to reduce the risk of enamel damage (12).

The sixty premolars with adhesive remnants were randomly divided into four groups of 15 premolars each (table 1). For each group, a different CM was used to remove the adhesive remnants: group 1- carbide bur (CB); group 2 - carbide bur with titanium nitride surface treatment + fine finishing with a carbide bur (CBCB); group 3 - glass fiber-reinforced composite bur (GFCB); group 4 - zirconia bur + fine finishing with a glass fiber-reinforced composite bur (ZBCB; figure 1)

The remaining 15 premolars with no adhesive served as a control group to assess the natural enamel surface. On each premolar a new instrument was used to eliminate the influence of tool wear on the results. Manufacturer's protocols were strictly followed for the use of the individual instruments, including rotation speed. Micromotor handpiece was used for all instruments, the rotation speed was 30000 revolutions per minute (rpm) for CB and CBCB, 10000 rpm for GFCB, and 15000-20000 rpm for ZBCB. Final fine enamel polishing was not included in the study design, as it cannot eliminate the grooves and pits on the surface (13-15).

On 10 premolars from each group evaluation of the enamel surface roughness was performed using an atomic force microscope (AFM; Dimension Icon, Bruker, MA, USA). Five scans were performed on each tooth in the area where the adhesive was removed, the exact location determined by

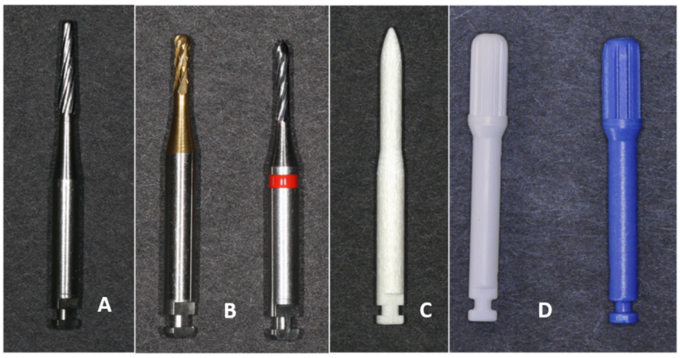

Figure 1. *Four CM instruments/set of instruments A) carbide bur, B) carbide bur with titanium nitride surface treatment + fine carbide bur, C) glass fiber-reinforced composite bur, D) zirconia bur + glass fiber-reinforced composite bur.*

Table 1. *The instruments used to remove adhesive remnants in each sample group.*

Samples groups	Adhesive remnant	Handpiece used	Rotation speed (rpm)	Instrument	Manufacturer
CB	Yes	Micromotor	30000	Carbide bur	NTI-Kahla GmbH, Kahla, Germany
CBCB	Yes	Micromotor	30000	Carbide bur with titanium nitride surface treatment + fine carbide bur	NTI-Kahla GmbH, Kahla, Germany
GFCB	Yes	Micromotor	10000	Glass fiber-reinforced composite bur	Stainbuster, Abrasive Technology Inc, Lewis Center, Ohio, USA
ZBCB	Yes	Micromotor	15000-20000	Zirconia bur + glass fiber-reinforced composite bur	DSI, Dental Solutions Israel, Ashdod, Israel
Control Group	No	None	None	None	None

Rpm – revolution per minute, CB – carbide bur; CBCB - carbide bur with titanium nitride surface treatment + fine diamond bur; GFCB - Glass fiber-reinforced composite bur; ZBCB - zirconia bur + glass fiber-reinforced composite bur

the overseeing orthodontist. For each scan, an area of 25x25 µm was probed on a flat section of the enamel surface. The scanning was performed using the PeakForce Tapping Technology and ScanAsyst probes (40 kHz, 0.4 N/m) with applied forces of about 5-7 nN, low enough to induce any surface damage. The AFM images were analyzed using the specialized Gwyddion software to obtain the values of individual parameters listed below. The evaluating parameters were adopted from the study by Karan *et al.* (8) and were as follows (all expressed in nanometers): arithmetic mean roughness parameter (Ra) - represents the arithmetic mean of all parts of the roughness profile; root mean square roughness parameter (Rq) - represents the root mean square of all values of the roughness profile; roughness depth (Rt) or total height of the R-profile - representing the sum of the highest peak of the profile and the depth of the deepest valley of the R-profile within the measured path. Overall, 50 measurements were obtained for each group and each measured parameter.

The remaining five premolars from each sample group were investigated by a scanning electron microscope (JSM-IT500HR JEOL InTouchScope™, Tokyo, Japan) at 5.0 kV with a 10 mm working distance and a 500× magnification. After obtaining the micrographs, one was randomly picked from each specimen. The presence of adhesive remnants was evaluated on each. Evaluation of the enamel surface was performed using the Enamel Damage Index (EDI) according to the exact procedure established by Schuler and van Vaese (16). The individual values were assigned by a single trained and experienced evaluator. The index has four levels: 0 - smooth enamel surface without grooves and cracks 1 - acceptable enamel surface with scattered grooves, covering only 1-10% of the enamel surface; 2 - rough surface with deep furrows or grooves covering 11-50% of the enamel surface; 3 - coarse furrows and wide grooves covering more than 50% of the enamel surface, damage visible to the naked eye. Observations using the electron microscope were performed without gold coating of the enamel surface, which can sometimes be an altering factor for the detection of lesions on the enamel surface (17).

To determine the time required to remove the adhesive residue with each instrument, the time interval in seconds needed for complete adhesive remnant removal was measured for each sample. Adhesive removal on all samples was performed by one experienced orthodontist in a standard manner, while an assistant recorded the time using stopwatches. Only the exact treatment time was measured, the timer was stopped for every replacement of the instrument in the CBCB and ZBCB groups.

Statistical analysis

The statistical analysis was performed using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA), NCSS 10 statistical software (2015, NCSS, LLC., Kaysville, UT, USA), and MS Excel 2016 (Microsoft Corp., Redmond WA, USA). The sample size was determined using G*Power 3.1.9.7. Considering the parameters obtained by examining pilot samples, effect size determined from pilot samples, 95% confidence level (1-α), and 80% test power (1- β), 8 samples for each group were deemed sufficient. The normal distribution of variables was assessed using Shapiro-Wilk tests for the quantitative variables. For the comparison of five independent samples, analysis of variance (ANOVA) was used, followed by Bonferroni post hoc tests. Qualitative data were evaluated using Fisher's exact test. All tests were conducted at a significance level of 5%. In case of comparing the times needed to remove adhesive remnants, *t*-test was used. To adjust for multiple comparisons and keep the familywise α at 0.05, the Bonferroni correction was used. The resulting α for a single comparison was 0.0167. Box plots were used to visualize the distribution of quantitative variables.

Results

Results of the evaluation of the enamel surface performed by AFM for intact enamel and enamel treated by different CM are listed in table 2. The lowest values of all three scores were achieved by GFCB (Ra=98.25; Rq=118.67; Rt=421.97), the roughness depth achieved by this instrument was lower than in intact enamel. The highest values of all three scores were found for enamel treated by CB (Ra=238.31; Rq=286.7; Rt=1034.22). The results for ZBCB were close to the results of intact enamel (Ra=144.71; Rq=175.33; Rt=605.95), the results of

Rt and Rq for CBCB were mediocre. The analysis of variance revealed statistically significant differences among the groups for all examined parameters - Ra (p<0.0001; power=1.0000), Rq (p<0.0001; power=1.0000), and Rt (p<0.0001; power=1.0000). The evaluation of the EDI index was performed on the SEM images (table 3, fig. 2A-E). No adhesive remnants were found on any teeth in the sample. The teeth treated with the GFCB instrument showed the smoothest enamel surface (1 tooth classified as 0, 3 teeth classified as 1, and 1 tooth classified as 2), while the teeth treated by CB had the worst EDI results. EDI results for ZBCB and CBCB were in between, with most of the teeth EDI 1 or 2. No statistically significant differences were found between the four CM according to Fisher's exact test (p=0.201). The treatment with the GFCB instrument takes significantly longer (mean = 116 s) compared to all other groups of teeth treated with other instruments (fig.3): the CB (mean = 66 s; p<0.0001; power=0.99689), the CBCB (mean = 49 s; p<0.0001; power=0.99999), and the ZBCB (mean = 61 s; p<0.0001; power=0.99759). No significant differences in time intervals were found among the other instruments.

Table 2. *Evaluation of the enamel surface performed by atomic force microscope.*

Parameters	Instrument	Average	SD	95% CI average		Minimum	Maximum	p
				Lover limit	Upper limit			
Ra	CB	238.31	79.16	215.81	260.81	95.28	431.20	
	CBCB	148.07	53.22	132.95	163.20	64.04	270.10	
	GFCB	98.25	40.69	86.68	109.81	31.79	218.10	<0.0001***
	ZBCB	144.71	53.97	129.38	160.05	61.25	304.10	
	Control	134.41	62.75	116.58	152.25	33.00	268.50	
Rq	CB	286.97	89.79	261.45	312.49	119.90	497.00	
	CBCB	178.58	60.83	161.29	195.87	79.20	304.90	
	GFCB	118.67	46.85	105.35	131.98	38.02	254.80	<0.0001***
	ZBCB	175.33	61.60	157.82	192.84	78.44	344.80	
	Control	158.98	69.89	139.12	178.85	42.58	305.90	
Rt	CB	1034.22	336.55	938.57	1129.87	400.06	1874.00	
	CBCB	630.70	202.24	573.22	688.17	324.30	1313.00	
	GFCB	421.97	161.17	376.16	467.77	146.60	880.60	<0.0001***
	ZBCB	605.95	206.07	547.38	664.51	278.20	1170.00	
	Control	539.69	225.86	475.50	603.88	138.60	1034.00	

****p<0,001; 95% CI – 95% confidence interval; Ra - mean roughness value - arithmetic mean value of the roughness profile; Rq - mean value - quadratic mean of all roughness profile values; Rt - depth of roughness - is the sum of the highest and lowest points of the measured area. CB – carbide bur; CBCB - carbide bur with titanium nitride surface treatment + fine diamond bur; GFCB - Glass fiber-reinforced composite bur; ZBCB - zirconia bur + glass fiber-reinforced composite bur*

Table 3. *Contingency table with EDI results.*

Instrument	Findings	EDI (surface roughness)				Total
		0	1	2	3	
CB	count	0	0	2	3	5
	%	0.0%	0.0%	40%	60%	100%
CBCB	count	0	1	2	2	5
	%	0.0%	20%	40%	40%	100%
GFCB	count	1	3	1	0	5
	%	20.0%	60.0%	20.0%	0.0%	100%
ZBCB	count	0	2	3	0	5
	%	5.0%	30.0%	40.0%	25.0%	100%
Total	count	1	6	8	5	20
	%	5.0%	30.0%	40.0%	25.0%	100%

EDI - enamel damage index; CB – carbide bur; CBCB - carbide bur with titanium nitride surface treatment + fine diamond bur; GFCB - Glass fiber-reinforced composite bur; ZBCB - zirconia bur + glass fiber-reinforced composite bur

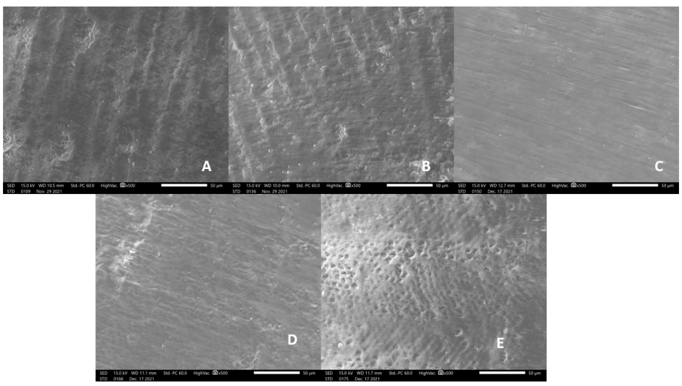

Figure 2. *Scanning electron microscope images of enamel at 500x magnification A) carbide bur, B) carbide bur with titanium nitride surface treatment + fine diamond bur, C) glass fiber-reinforced composite bur, D) zirconia bur + glass fiber-reinforced composite bur, E) intact enamel.*

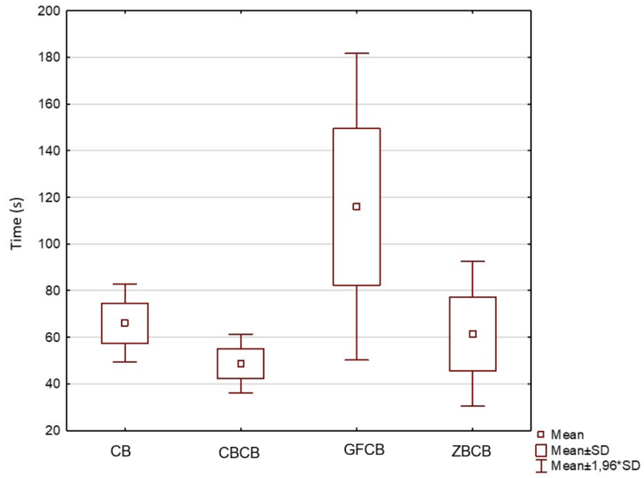

Figure 3. *The mean values and standard deviations of time needed to remove the adhesive remnants for each instrument. CB – carbide bur; CBCB - carbide bur with titanium nitride surface treatment + fine carbide bur; GFCB - glass fiber-reinforced composite bur; ZBCB - zirconia bur + glass fiber-reinforced composite bur.*

Discussion

Care must be taken when removing adhesive remnants after fixed appliance or aligner treatment as any roughness of the enamel surface may result in excessive plaque accumulation and increased pigment deposition (18,19). Even if the enamel surface appears clinically undamaged minuscule adhesive remnants or grooves and scratches from inadequately used instruments might surpass the threshold roughness value for bacterial adhesion. Bonetti *et al.* (20) observed residual adhesive in 20% of the teeth examined in vivo with a scanning electron microscope. We have not found any adhesive remnants on the teeth in the sample, probably due to easier cleaning of the adhesive remnants under in vitro conditions with optimal lighting.

Iatrogenic scratching, grooving or infractions of the enamel may occur during mechanical bracket removal due to force applied by pliers or possible direct mechanical damage (21). In the present study before bracket bonding a thin layer of petroleum jelly was applied to its base, which caused the bond to break at the bracket base and the adhesive, leaving all adhesive on the tooth (10). This procedure facilitated smooth bracket removal with low force. Therefore, any alteration to the enamel surface found was attributed solely to the instrument used for adhesive remnants removal.

To compare the effects of the instruments on the enamel surface, we selected the four most frequently used CM: carbide bur, which is considered the gold standard for removal of the adhesive remnants; as well as carbide bur with nitride treatment and composite or zirconia bur. Although CB are considered safe, when used incautiously with high pressure and higher than recommended rotation speed they can cause enamel pitting and pulpal thermal changes (22,23). In the present study, the speed was always set according to the manufacturer's recommendations to test the I/SI efficiency properly, on the other hand, Zachrisson *et al.* (2) in 1979 recommended lower speeds for safety reasons for CB.

Results from SEM showed that the enamel surface after adhesive remnants removal with the GFCB was the smoothest while the surface treated by CB presented the worst results, however, the differences between the four investigated CM methods were insignificant. Results from an electron microscope might be biased due to the subjective assessment of the EDI by the evaluator and therefore inaccurate. Shah *et al.* (10) compared the effect of the GFCB instrument on the enamel surface with other three fine polishing systems using SEM together with a surface roughness tester, and their results confirmed that the enamel surface appeared closest to natural enamel when using the GFCB instrument. Garg *et al.* (24) compared the GFCB with another composite bur and a CB using the same investigative method. Their results showed a significantly smoother enamel surface when using both composite burs compared to the standard CB. In the present study SEM results were complemented by an AFM investigation to obtain objective values of enamel roughness since AFM is more sensitive to surface topography even down to the nanoscale (25). The results of all three investigated roughness parameters indicate that the smoothest enamel surface was achieved with the GFCB instrument. It produced the least rough enamel surface compared to CB, CBCB, and ZBDB. The resulting Ra, Rq, and Rt values were even lower after using the GFCB instrument than in an intact enamel. CBCB created a satisfactory final enamel surface according to all Ra, Rq, and Rt values. Enamel treated by CB achieved the highest Ra and Rt scores, while the highest Rq score was estimated for ZBCB. Mohebi *et al.* (9) reached a similar conclusion when comparing the effect of the GFCB versus the CB by AFM in a high-speed and low-speed handpiece. Karan *et al.* (8) also confirmed that the GFCB left a smoother enamel surface than the CB. However, Sugsompian *et al.* (26) concluded in their study that all investigated clearance methods (Sof-Lex disc, sandblaster, tungsten carbide bur, and white stone bur) resulted in a clinically acceptable enamel surface roughness.

Chair time is nowadays the most expensive part of orthodontic treatment, therefore cleaning of the adhesive remnants should be as quick and effective as possible. Removing the adhesive remnants in perfect in vitro conditions by an experienced orthodontist with CBCB took less than a minute and with CB 66 seconds on average. Using the GFCB instrument it took almost twice as much time. Caution must be drawn when interpreting this result - this study was done in vitro, thus the result might not reflect the clinical situation. In the case of sets of instruments (CBCB and ZBCB) the clinical treatment time might be higher because of the need to replace the instruments, however in reality the replacement occurs just once for each dental arch, which should not affect the time interval needed for adhesive remnants removal much. For the time-consuming nature of the preparation with the composite instruments, Mohebi *et al.* (9) recommended starting with the removal of the thickest layers of adhesive using a carbide bur and completing the work with a composite bur when only a thin layer of adhesive is present, which might decrease the clearance duration.

Clinically patients' discomfort might be a problem during adhesive remnants removal. While in some studies vibrations of specified frequency and magnitude are discussed to be effective in pain relief during the active phase of orthodontic treatment, others report that vibrations of the tooth during drilling a cavity cause unpleasant feelings for patient (27,28). Clearing the adhesive remnants with burs corresponds more with the latter and might differ according to the used speed of the bur (23). Yet, there are no studies of patient discomfort during adhesive remnants removal by burs, most studies concentrate on the pain felt during mechanical removal of the brackets (29,30). The personal perception of the operator in the present study was, that while working with a zirconia bur the vibrations were higher than while using other tools. Further studies are necessary to estimate the levels of patient discomfort using different instruments for adhesive remnants removal.

Instruments for adhesive remnants removal are usually not disposable, but their durability is not much discussed or researched. It is usually up to the treating clinician to evaluate the instrument suitable for its continued use. In studies dealing with the effect of the instrument on the enamel surface, a new instrument is usually used for each tooth to avoid biased results by instrument wear, as in the case of the present study. However, it is not clearly stated how often the instrument should be changed in everyday practice. According to a study by Pines and Schulman, the greatest edge abrasion of the CB occurs when used directly on enamel and edge blunting occurs after preparation of approximately 11 enamel surfaces, *i.e.*, one dental arch (31). In addition to edge abrasion caused by the inorganic filler, the reduction in tool efficiency also results in clogging of the sawdust space between the blades. On the other hand, according to the manufacturer's leaflet, GFCB remains sharp thanks to the glass fibers throughout use, reducing its mass. There are no publications about the wear of the CBCB and ZBCB that the authors are aware of. More studies on the wear of instruments used for adhesive remnants clearance are needed as studies on brand-new instruments may not represent a standard clinical situation.

This study has some limitations that should be considered when interpreting the results. A limitation of the current study is that it does not utilize the repeated investigation method (i.e. one investigation before bracket placement and the second after its removal for AMF and SEM investigations), as using the control sample might not bring the exact results. Another limitation is the possibility of overlooking smaller grooves or scratches during the initial inspection of the enamel surface by visual inspection under dental light and magnifying glass, which could have an impact on the results. Also, although every bracket base was coated with petroleum jelly and minimal strength was necessary to debond the bracket, the possibility of enamel damage while removing the brackets with pliers cannot be excluded. Adhesive remnants were cleaned by hand by one experienced orthodontist, therefore differences in applied pressure on the individual instruments cannot be excluded.

Conclusion

The results have shown significant differences in the enamel roughness and treatment time among the different clearance methods in vitro. The Glass fiber-reinforced composite bur achieved the smoothest enamel surface, but it required the longest processing time. Using a carbide bur was the fastest clearance method, but the enamel surface roughness was the highest. Using the set of instruments - carbide bur with titanium nitride surface treatment and fine carbide bur - proved to be a fast method to remove the remaining adhesive with satisfying remaining enamel roughness.

Türkçe öz: *Ortodontik yapıştırıcı çıkarıldıktan sonra mine yüzey pürüzlülüğü. Dört temizleme yöntemini karşılaştıran bir in vitro çalışma. Amaç: Yapıştırıcı kalıntılarının çıkarılması, ortodontik tedavi sonuçlarını etkileyen son önemli adımdır. En kısa sürede en pürüzsüz mine yüzeyini hangi yöntemin elde ettiğini belirlemek amacıyla dört farklı ortodontik yapıştırıcı temizleme yöntemi (CM) değerlendirildi. Gereç ve Yöntem: Ortodontik amaçlarla çekilen 75 sağlam küçük azı dişi çalışmaya dahil edildi, bunların altmışına ortodontik braket yapıştırıldı ve daha sonra çıkarıldı, on beşi kontrol grubu olarak kullanıldı. Her bir CM, 15 küçük azı dişinin yüzeyini temizlemek için kullanıldı: karbür frez (CB), titanyum nitrür yüzey işlemi + ince karbür frez (CBCB), cam elyaf takviyeli kompozit alet (GFCB), zirkonya frez + cam elyaf takviyeli kompozit frez (ZBCB). İşlem süresi kaydedildi. Her gruptan on küçük azı dişinde, atomik kuvvet mikroskobu ile ortalama pürüzlülük (Ra), pürüzlülük profil değeri (Rq) ve pürüzlülük derinliği (Rt) tahmin edilerek mine yüzeyi değerlendirildi. Kalan beş küçük azı dişinde taramalı elektron mikroskobu ile Mine Hasar Endeksi (EDI) değerlendirildi. Bulgular: Tüm değerlendirilen parametrelerde - Ra (p<0.0001), Rq (p<0.0001) ve Rt (p<0.0001) - önemli farklılıklar gözlemlendi. GFCB, tüm parametrelerde en pürüzsüz yüzeyi sergiledi. En düşük EDI, GFCB ile tedavi edilen dişlerde gözlemlendi, ancak farklar önemli değildi. GFCB ile çalışmak en uzun süreyi aldı (ortalama 116s) ve en kısa süre CBCB ile çalışıldı (ortalama 49s). Sonuç: CB kullanımı en hızlı temizleme yöntemi olsa da, mine yüzey pürüzlülüğü en yüksekti. CBCB alet seti ile temizleme, kalan mine pürüzlülüğünde tatmin edici sonuçlarla hızlı bir yöntem olduğunu kanıtladı. Anahtar kelimeler: mine pürüzlülüğü, temizleme yöntemi, ortodonti, yapıştırıcı, diş yüzeyi*

Ethics Committee Approval: The survey was approved by the ethics committee of the Institutional Review Board EK/1/25/03/2021.

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