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Original article

Early versus delayed rebonding of orthodontic brackets

Farzaneh Ahrari[a], *Maryam Poosti*[b,*], *Majid Akbari*[c], *Koorosh Sadri*[d]

[a] *Assistant Professor of Orthodontics, Dental Materials Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran*
[b] *Assistant Professor, Department of Orthodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran*
[c] *Assistant Professor, Department of Operative Dentistry, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran*
[d] *Private practice, Mashhad, Iran*

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ABSTRACT

Objectives: There are controversial reports regarding the effect of repeated bonding on shear bond strength (SBS) of orthodontic attachments. The aim of this study was to evaluate the SBS of brackets following early and delayed rebonding, and after employing different methods of composite removal.
Materials and methods: Sixty eight premolars were randomly assigned into 4 groups. After initial debonding and recording the SBS, the adhesive remnants in the first group were removed by a round bur, in the second group by a green rubber wheel, and in the third and fourth groups by 12-fluted tungsten carbide burs, all of them connecting to a low speed handpiece. In the fourth group following adhesive removal, the teeth were kept in a simulated oral environment for one month. Then, rebonding was performed and the second SBS was measured. Two representative samples from each group were examined under a scanning electron microscope following adhesive removal. The data were analyzed by ANOVA, Paired sample t-test and Chi-Square test.
Results: In the first group, the rebonding strength was decreased significantly ($p < 0.05$), while composite removal with a tungsten carbide bur or a green rubber wheel did not affect SBS significantly ($p > 0.05$). Late rebonding of brackets had no effect on the SBS ($p > 0.05$).
Conclusions: Postponing rebonding to the next visit does not improve the SBS significantly. It is recommended to use a tungsten carbide bur or a green rubber wheel, and not a round bur for removing adhesive remnants following debonding of orthodontic brackets.

1. Introduction

Bracket debonding due to inappropriate occlusal forces, or intentional removal of brackets to reposition them for achieving ideal tooth position are not rare experiences for orthodontists during treatment. According to Lovius *et al*[1] debonding of brackets occurs in 16- 23% of orthodontic patients, therefore several teeth have to be rebonded in daily orthodontic practice.

The effect of repeated bonding, on the same enamel surface, has been investigated by many authors and the results

* Corresponding author: Department of Orthodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.
E-mail addresses: poustim@mums.ac.ir, poustimaryam@yahoo.com (M. Poosti).
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are inconsistent on this subject. Some studies showed that there were no significant differences between SBS of fresh and rebonded surfaces,[2,3] while others reported increased,[4–6], decreased[7,8] and inconsistent results[8] in shear bond strength, after the second bonding of enamel surfaces.

After etching, the resin applied to enamel surface penetrates into dissolved areas with the average depth of 5-10 μm,[9] showing tag lengths up to 170 μm.[10] Fine resin tags remain embedded in the enamel after debonding and will probably reduce mechanical retention.[10] The repair of etched enamel surfaces which are free from adhesives begins approximately two days after the etched surface is exposed to the oral environment,[11] but it may take up to 3 months before full remineralization occurs, or the superficial layer is removed by abrasive mechanisms.[12]

The aim of the present study was to evaluate the shear bond strength of orthodontic brackets following early and delayed rebonding and after employing different methods of composite removal.

2. Materials and methods

Sixty eight upper premolars that were extracted for orthodontic reasons were selected. The teeth were examined by a lens of × 4 magnification to eliminate those with hypoplastic or cracked enamel. Each tooth was embedded in a plastic mold with a self-curing acrylic resin so that the enamel surface of the tooth would be perpendicular to the bottom of the mold. The teeth were randomly assigned into 4 groups of seventeen and each tooth was recorded by a numbered, so it was possible to compare the SBS after primary and secondary debondings.

Primary bonding/debonding: The teeth were cleaned for 5 seconds, with non-fluoride pumice slurry and a nylon brush which was attached to a low speed handpiece, etched for 30 seconds with 37% phosphoric acid, rinsed for 15 seconds, and then dried with an oil-free air spray. A thin layer of Transbond XT primer (3 M Unitek, Monrovia, Calif) was applied on the enamel surface. Maxillary first premolar stailnless steel brackets (Dentaurum, Ispringen, Germany) were then bonded with Transbond XT adhesive (3 M Unitek) and cured by Bluephase C8 (Ivoclar, Vivadent, Schaan, Leichtenstein) light-emitting diode (LED) at 650 mW/cm2 for 40 seconds (10 seconds from each side of bracket). The teeth were later immersed in deionized water for 24 hours at 37°C. Shear bond strength (SBS) test was performed by Zwick testing machine (Zwick GmbH & Co, Ulm, Germany) using a cross head speed of 1.0 mm/min. The SBS value was recorded in newtons, and then converted to MPa by dividing the measured force by the bracket surface area (10.92 mm^2). After debonding the teeth were examined by a stereomicroscope with ×10 magnification and the ARI was assessed regarding the remnant resin material on the enamel surface, as defined by Artun and Bergland.[13]

0: no composite remained on the tooth surface, 1: less than 50% of the composite remained on the tooth surface, 2: more than 50% of the composite remained on the tooth surface, 3: the entire composite remained on the tooth surface, with a distinct impression of the bracket base.

Secondary bonding/debonding: After primary debonding, composite remnants in the experimental groups were removed from the enamel surfaces of the teeth by different rotary instruments operating in a low speed handpiece at a speed of 25000 revolutions per minute without water, as follows:

Group 1: Residual composite was removed by a round bur.

Group 2: Residual composite was removed by a green rubber wheel.

Group 3: Residual composite was removed by a tungsten carbide (TC) bur.

Group 4: Residual composite was removed by a tungsten carbide bur and the teeth were immersed in a Fuzayama-Meyer artificial saliva solution[14] for 1 month at 37°C. To simulate abrasive forces of tooth brushing in oral environment a piston-action brushing machine was employed under a standardized load. This device consisted of 8 heads to hold toothbrushes connected to a camshaft driven by a motor/gearbox system and a control unit. A toothbrush with soft nylon bristles (Oral-B Indicator toothbrush) was fitted into each head, and the specimen block was then mounted in the opposing specimen holder. Care was taken that the filaments in each tuft of the brush were perpendicular to the buccal surface of the enamel. Fourteen hundred strokes (45 strokes per day, equal to twice daily tooth brushing)[15,16] were performed on each specimen at a speed of 235 strokes (complete forward and reverse movement) per minute, with a load of 300 g, using 5 mL of toothpaste slurry (weight ratio of toothpaste to deionized water was 1:4, Crest toothpaste).

The removal of composite was considered complete when the tooth surface seemed smooth and free of composite to the naked eye under the light of an operator lamp. All experiments were performed by the same investigator. After adhesive removal, two samples in each group were used for SEM (Scanning Electron Microscope) analysis. Rebonding was performed by new brackets in all groups, with the same procedure detailed in primary bonding. Teeth were kept in deionized water for 24 hours at 37°C, then SBS and ARI scores were measured again, as described previously.

The data were analyzed by SPSS software (Statistical Package for Social Sciences, Version 11.0, Ill.). After the normal distribution of the data and equality of variances were confirmed by Kolmogorov-Smirnov and Levene tests respectively, one way analysis of variance (ANOVA) was used to compare SBS between different groups at each debonding sequence. Paired t-test was used to compare the change in SBS from primary to secondary debonding within each group. Fisher's exact test was applied to assess the difference in ARI scores of the study groups at each debonding. In all statistical tests the significance level was considerd 0.05.

3. Results

The results of ANOVA demonstrated that there was no significant difference in mean SBS of 4 groups after primary and secondary debonding sequences (Table 1).

Paired t-test showed a significant decrease in SBS of group 1 (round bur) from primary to secondary debonding ($p < 0.05$), but the changes in SBS of other groups were not statistically

Table 1 – SBS (MPa) after primary and secondary debonding. Data are presented as mean ± SD.

	Primary bonding	Secondary bonding
Group 1 (n = 15)	9.4 ± 2.36	8.1 ± 1.77*
Group 2 (n = 15)	9.17 ± 1.92	9 ± 1.03
Group 3 (n = 15)	9.51 ± 2.95	9.74 ± 2.2
Group 4 (n = 15)	9.21 ± 2.3	10.06 ± 1.77
ANOVA test:	$p = 0.11$	$p = 0.85$

significant between primary and secondary debonding sequences ($p > 0.05$).

Fisher's exact test showed that ARI scores of the study groups were not significantly different after the first and the second debondings (Table 2).

SEM evaluation revealed that adhesive islands were observed after composite removal in all groups, and enamel scars were obvious after adhesive elimination with rotary instruments (Figures 1–4).

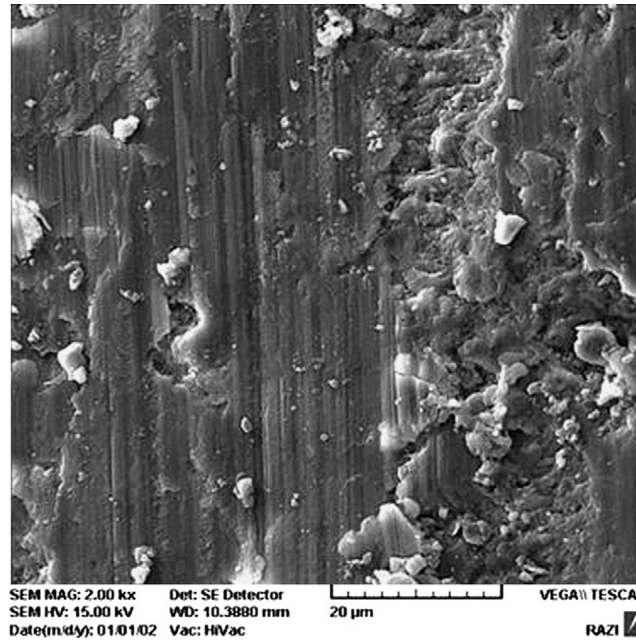

Figure 1 – SEM appearance of enamel after adhesive removal by a round bur, observed with ×2000 magnification. Considerable amount of adhesive is remained and coarse scratches are seen on the tooth surface.

4. Discussion

Bond failure is an unfavorable problem that frequently happens during fixed orthodontic therapy,[1] and there are controversial findings regarding the bond strengths of rebonded brackets.[4,7,17]

In the fourth group of this study, the effect of enamel remineralization accompanied by mechanical abrasion from tooth brushing was evaluated on rebonding of orthodontic brackets. Some clinicians believe that when bond failure occurs repeatedly in one appointment, they had better to remove the adhesive remnants from the enamel surface and allow the enamel to restore itself until the next appointment. However, the findings of the present study do not corroborate this belief. Although a slight increase in SBS was detected between the primary and secondary debondings of the late rebonded group, this change was not statistically significant, implying that remineralization of etched enamel surfaces, or elimination of superficial enamel by mechanical abrasion, does not dramatically affect the SBS values of rebonded brackets.

We also evaluated the efficacy of different rotary instruments in adhesive removal and their effects on shear rebond strength. Although there was no significant difference in SBS of different groups at each debonding sequence, by comparing SBS within each group between primary and secondary debondings, SBS significantly decreased when a low speed round bur was used to remove the remaining adhesive. This could be interpreted as inefficiency of this instrument in composite removal after debonding, despite its popularity among some dentists as "a tool for composite removal without abrading the enamel surface". There was no significant difference between primary and secondary debondings in the green rubber wheel and TC groups. Previous studies have reported controversial findings regarding rebonding strengths of orthodontic brackets. Eminkahyagil et al[4] found that Sof-Lex discs and low speed TC burs could increase enamel roughness after resin removal, resulting in higher rebond strength than the initial bonding. Mui et al[3] reported that enamel preparation by a low speed TC bur followed by acid etching created bond strengths comparable to or more than the primary SBS. Contrary to the present study, Bishara et al[7] claimed that rebonded teeth had significantly lower SBS compared with initial debonding. In another study Bishara et al[8] found that rebonded teeth had lower and inconsistent bond strengths with either increase or decrease in SBS. In SEM

Table 2 – Comparison of ARI scores after primary and secondary debondings.

	ARI scores after primary debonding				ARI scores after Secondary debonding			
	0	*1*	*2*	*3*	*0*	*1*	*2*	*3*
Group1	0	7	6	2	2	9	3	1
Group2	0	4	8	3	0	7	7	1
Group3	1	7	6	1	0	5	9	1
Group4	2	8	4	1	1	9	4	1
Fisher's exact test:	*$p = 0.55$*				*$p = 0.49$*			

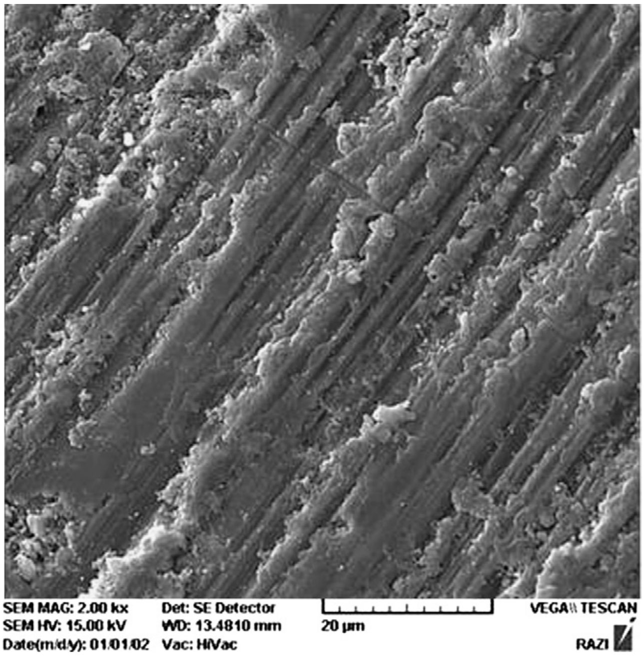

Figure 2 – SEM appearance of enamel after adhesive removal by a green rubber wheel, observed with ×2000 magnification. Islands of remnant composite are seen on the tooth surface.

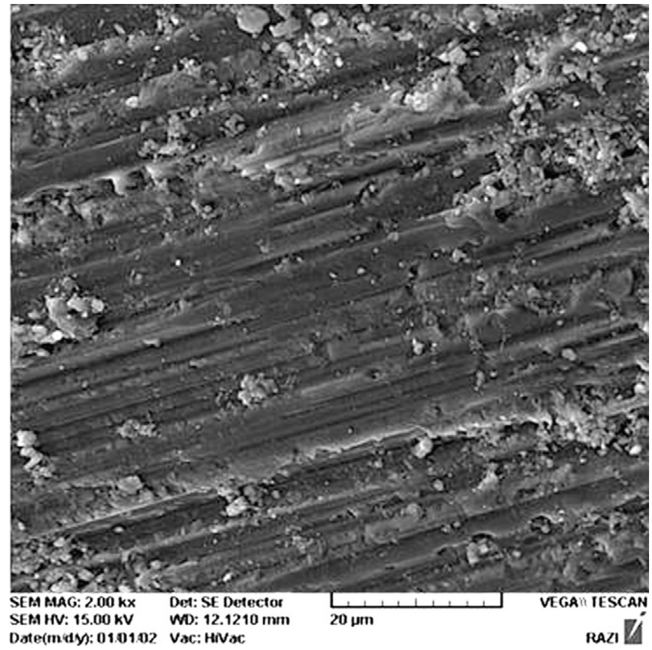

Figure 4 – SEM appearance of enamel after adhesive removal by a tungsten carbide bur and immersion of the tooth in a simulated oral environment for 1 month, observed with ×2000 magnification. Islands of remnant composite are seen on the tooth surface, but the surface seems smoother and with fewer scratches, compared with other groups.

evaluation, they observed adhesive remnants embedded in the enamel surface, even after cleaning the surface with finishing burs, resulting in decreased enamel roughness and so the bond strength.[7,8]

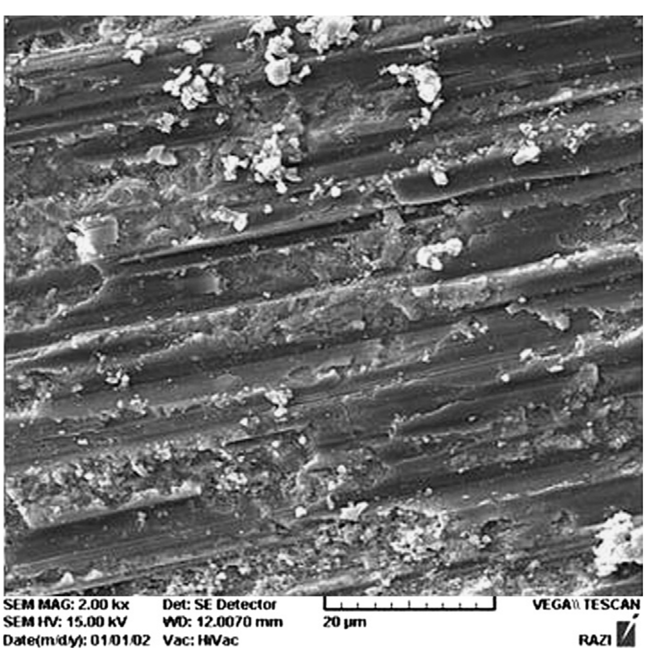

Figure 3 – SEM appearance of enamel after adhesive removal by a tungsten carbide bur, observed with ×2000 magnification. Islands of remnant composite are seen on the tooth surface.

In the present study enamel scratches and scars were apparent in SEM images of all groups following adhesive removal. This phenomenon has been reported in previous studies.[4,17] Our data proved that the low speed TC bur was efficient in adhesive removal on the enamel, but injuries were inevitable. This finding is in agreement with the study of Eminkahyagil et al[4] who reported that the application of TC burs was effective in residual resin cleanup, but SEM images demonstrated enamel scarring with TC burs operated in both low and high speed handpieces. Zachrisson and Arthun,[18] van Waes et al,[19] and Hosein et al[20] concluded that low speed TC burs created the finest scratches, with minimal enamel loss.

Green rubber wheel was the other rotary instrument used for adhesive removal, demonstrating acceptable results in both SBS measurment and SEM examination, but it was time consuming. Similarly, Campbell[21] found this method effective, but cumbersome for most clinicians.

It is worth to mention that the ranking of bonding strength in dental adhesives appears to be test dependant, with microtensile bond test appearing to be more accurate in differentiating among stronger adhesives.[22] The overall trend is that macro-tests with bonding surfaces around 7 mm^2 as encountered in shear and tensile tests deliver lower bond strength values than their equivalent micro-tests with bonding surface around 1 mm^2.[23] Since we compared bond strength with a single adhesive in different procedures and macroshear was applied in all tests, therefore this test could be comparable throughout the experiment.

The ARI scores did not differ significantly among groups after primary and secondary debondings, indicating a higher number of mixed type failure in all groups. Clinically, favorable failure site is between adhesive and bracket because adhesive-enamel failures could lead to enamel fractures.

In the present study, the shear bond strength of all rebonded groups were higher than 7.8 MPa, a point which was suggested by Reynolds[24] as a minimum bond strength requirement in clinical orthodontic practice. However, since most in vitro experimental protocols are not capable of simulating SBS in clinical situation,[25] further in vivo studies are recommended on shear rebond strength of orthodontic brackets.

5. Conclusion

The present findings indicate that:

1- Postponing the rebonding procedure to the next visit in order to allow remineralization does not significantly increase the SBS.
2- A green rubber wheel or a tungsten carbide bur which were operated in a low speed handpiece resulted in comparable bond strength with initial debonding.
3- The application of a low speed round bur was inefficient for adhesive removal and caused significantly lower rebond strength, thus this method could not be recommended for adhesive removal following debonding of orthodontic brackets.

Conflict of interest

The authors have reported no conflicts of interests.

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Riassunto

Obiettivi: *Gli studi relativi agli effetti di bondaggi ripetuti sulla forza di resistenza al taglio degli attacchi sono controversi. Il presente contributo ha l'obiettivo di valutare la resistenza al taglio degli attacchi ortodontici dopo ribondaggio precoce e ritardato utilizzando diversi metodi di rimozione del composito.*

Materiali e metodi: *68 premolari sono stati suddivisi in maniera randomizzata in 4 gruppi. Dopo lo sbondaggio iniziale e la registrazione dei valori di resistenza al taglio degli attacchi, nel primo gruppo è stato rimosso l'adesivo residuo utilizzando una fresa tonda, nel secondo gruppo utilizzando un disco in gomma verde e nel terzo e quarto gruppo utilizzando uno fresa al carburo di tungsteno a 12 lame. Tutti gli strumenti erano collegati ad un manipolo a bassa velocità. Dopo l'eliminazione dell'adesivo, gli elementi dentali del quarto gruppo sono stati tenuti per un mese in un ambiente che simula le condizioni del cavo orale. Successivamente è stato effettuato il rebonding ed è stata misurata una seconda volta la resistenza al taglio. Dopo la rimozione dell'adesivo i campioni rappresentativi dei quattro gruppi sono stati sottoposti ad a microscopia a scansione elettronica. I dati ottenuti sono stati poi valutati con ANOVA, test t di campioni accoppiati e test Chi Quadro.*

Risultati: *Nel primo gruppo, la forza di adesione dopo il ribondaggio è risultata significativamente diminuita ($p<0.05$), mentre la rimozione del composito con la fresa al carburo di tungsteno o con il disco di gomma verde non ha avuto un effetto significativo sui valori di adesione ($p>0.05$).*

Conclusioni: *Ritardare il bondaggio alla visita successiva non migliora in maniera significativa la forza di resistenza al taglio degli attacchi ortodontici. Si raccomanda di utilizzare le frese al carburo di tungsteno e non la fresa tonda per rimuovere l'adesivo residuo dopo aver sbondato gli attacchi ortodontici.*

Résumé

Objectif: *Les études concernant les effets de collages répétés sur la résistance au cisaillement sont controversées. Le présent travail a le but d'évaluer la résistance au cisaillement des attaches orthodontiques après recollage précoce et retardé, avec des méthodes différentes d'enlèvement du composite.*

Matériels et méthodes: *68 dents prémolaires ont été subdivisées, de façon aléatoire, en 4 groupes. Après le décollage initial et l'enregistrement des valeurs de résistance au cisaillement des attaches, l'adhésif restant à été enlevé de la façon suivante: à l'aide d'une fraise ronde dans le premier groupe, à l'aide d'une meulette en caoutchouc vert dans le deuxième groupe et au moyen de fraises en carbure de tungstène à 12 lames dans les deux autres groupes (3 et 4). Tous les instruments ont été reliés à une pièce de main à faible vitesse. Après l'élimination de l'adhésif, les elements dentaires du quatrième groupe ont été gardés, pendant un mois, dans un milieu qui simulait les conditions de la cavité buccale. Par la suite, le recollage a été réalisé et la résistance au cisaillement à été mesurée une deuxième fois. Après l'enlèvement de l'adhésif, les échantillons representatives des quatre groupes ont été soumis au microscope électronique à balayage (MEB). Les données obtenues ont été ensuite évaluées au moyen du test ANOVA, test t d'échantillons appariés et test du khi carré.*

Résultats: *Dans le premier groupe, la force d'adhésion après recollage s'est avérée réduite de façon significative ($p<0.05$), alors que l'enlèvement du composite à l'aide de la fraise en carbure de tungstène ou bien de la meulette n'a a pas eu d'impact important sur les valeurs d'adhésion ($p>0.05$).*

Conclusion: *Retarder le collage à la séance suivante n'entraîne pas une amélioration sensible de la résistance au cisaillement des attaches orthodontiques. Nous conseillons l'utilisation des fraises en carbure de tungstène ou de la meulette et non pas de la fraise ronde pour enlever l'adhésif restant après décollage des attaches orthodontiques.*

Resumen

Objetivos: *Los estudios que atañen a los efectos de cementados repetidos en la resistencia al cizallamiento (SBS) están controvertidos. El presente trabajo tiene el propósito de valorar la resistencia al cizallamiento de los brackets ortodónticos después de recementación temprana y retrasada, y con diferentes métodos de remoción del composite.*

Materiales y métodos: *68 premolares fueron subdivididos, de manera aleatoria, en 4 grupos. Después del descementado inicial y registro de los valores de resistencia al cizallamiento de los brackets, la remoción del adhesivo remanente fue realizada del* *siguiente modo: por medio de una fresa redonda en el primer grupo, de una rueda de goma verde en el segundo grupo y de una fresa de carburo de tungsteno de 12 hojas en los dos otros grupos (3 y 4). Todos los instrumentos estaban conectados a una pieza de mano de baja velocidad. Después de la eliminación del adhesivo, los elementos dentales del cuarto grupo fueron mantenidos, durante un mes, en un ambiente que simulaba las condiciones de la cavidad bucal. Posteriormente, fue efectuado el recementado y fue medida, por segunda vez, la resistencia al cizallamiento. Después de la remoción del adhesivo, las muestras representativas de los cuatro grupos fueron sometidas a microscopio electrónico de barrido. Los datos obtenidos fueron valorados por medio de ANOVA, prueba de T para maestra apareadas y prueba de Chi-cuadrado.*

Resultados: *En el primer grupo, la fuerza de adhesión después del recementado resultó ser muy disminuida ($p < 0.05$), mientras que la remoción del composite por medio de la fresa de carburo de tungsteno o de la rueda de goma verde no impactó significativamente en los valores de adhesión ($p > 0.05$).*

Conclusiones: *Retrasar el cementado a la consulta siguiente no mejora, de manera significativa, la resistencia al cizallamiento de los brackets ortodónticos. Recomendamos que utilicen la fresa de carburo de tungsteno o la rueda de goma verde y no la fresa redonda para remover el adhesivo remanente después de descementar los brackets ortódonticos.*

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