

COMPARATIVE EVALUATION OF FOUR OFFICE RECONDITIONING METHODS FOR ORTHODONTIC STAINLESS STEEL BRACKETS ON SHEAR BOND STRENGTH – AN IN VITRO STUDY

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ABSTRACT

An invitro study was conducted to determine a simple and effective method for reconditioning stainless steel orthodontic brackets in the orthodontic office. In total, 120 new brackets were direct bonded using light cure composite to extracted human premolar teeth, then debonded and the shear bond strength recorded as a control for the reconditioning process. The debonded brackets were divided into four groups containing 30 brackets each and each group reconditioned using different techniques as follows: (1) roughened with green stone, (2) direct flamed, (3) flamed followed by ultrasonically cleaned, (4) sandblasted. After reconditioning, the brackets were then rebonded to the premolar teeth after the enamel surfaces had been re-prepared, and their bond strengths measured. The results showed that bracket reconditioned by sandblasting had the highest mean shear bond strength among the reconditioning methods tested, indicated that sandblasting was the most effective in removing composite. Brackets that had only been roughened with green stone and direct flamed had the lowest bond strength, followed by that had been flamed followed by ultrasonic cleaning.

KEY WORDS: Reconditioning, Orthodontic Brackets, Direct Bonding, Debond, Bond strength.

INTRODUCTION:

Orthodontists are commonly faced with the decision of what to do with loose brackets, and or with inaccurately located brackets that need repositioning during treatment¹. Recycling orthodontic brackets is an option available to practitioners, where brackets need to be rebonded back onto a tooth. Postlethwaite (1992) reported that as many as 75 per cent of American orthodontists were recycling their brackets in the early 1990s². The major advantage of recycling is the economic saving, which could be as high as 90 per cent, due to the fact that a single bracket can be reused up to five times³. The disadvantages of recycling may include a reduction in bracket quality, loss of identification marks, lack of sterility and increased risk of cross-infection.⁴ Commercial recycling, whether by heat or chemical means, leads to a degree of metal loss in certain areas of the bracket and a reduction in the diameter of the mesh strands.^{5,6} Most investigators have reported a reduction in bond strength after commercial

recycling, varying between 6 and 20 percent^{1,6}, although this may be as high as 35 per cent for finer-meshed bases.⁵ In 1986, as reported by Postlethwaite (1992), Smith found that there was no significant decrease in bond strength after the recycling process by two companies. There was, however, a significant decrease in the mesh wire diameter. This appears to be in agreement with Wheeler and Ackerman (1983), who reported that there was no correlation between the decrease in mesh wire diameter and bond strength.⁶

Further criticism of commercial recycling is the long turnaround time of the process and the inability to recognize brackets that have been recycled more than once. Brackets are labelled for single use only, and there is the possibility of litigation as a result of the reuse of brackets.^{7,8} In addition, commercially recycled brackets are more prone to corrosion, particularly brackets made from type 304 (AISI) stainless steel.⁹

To overcome the delays associated with commercial recycling, various chair side reconditioning techniques have been developed. Roughening a debonded attachment with a greenstone has been reported to lead to a smoother surface devoid of undercuts^{1,10} and reduced the chemically active groups available for bonding.¹¹ Brackets have also been flamed in a Bunsen flame for 3–5 seconds, quenched in water, sandblasted for 5–10 seconds to remove the remaining debris, then electropolished for 20 seconds.^{10,12} Regan *et al.* (1993) reported a 41 percent decrease in the bond strength of flamed brackets, which was equal to the decrease seen with brackets that had been roughened with a greenstone only.¹⁰ Air abrasion has also been used to recondition debonded brackets; a bracket was held approximately 5 mm from the tip of a microetcher and etched with 90 µm aluminium oxide at 90 psi until all visible bonding material was removed from the bracket base. This usually took 15–30 seconds. The results indicated no significant difference in the shear bond strengths of new and sandblasted brackets.¹³

The objective of this study was to find a rapid office method of treating recently debonded brackets to produce clinically acceptable bond strengths. This would be of clinical value where replacements are unavailable or expensive, and at the same time would avoid the delays associated with commercial recycling.

Objectives

The objective of this in-vitro study was to find a simple and effective office method of treating recently debonded brackets to produce clinically acceptable bond strengths.

Materials and methods:

A total of one hundred and twenty extracted human premolar teeth were collected over a period of six months. Soon after the extraction, the teeth were cleaned and stored in 70% ethyl alcohol as reported in the literature¹⁴.

The criteria for tooth selection included intact buccal enamel, no history of any pretreatment with chemical agents, e.g., hydrogen peroxide, no cracks present due to the extraction forceps, and no caries. The teeth were cleansed and polished with pumice

and rubber prophylactic cups for 10 seconds and washed with water.

DPI cold cure acrylic resin was used to make the blocks (DPI Wallance Street, Bombay). All the teeth were embedded in acrylic blocks poured in PVC rings.

ENLIGHT Light cure adhesive system (Ormco corporation) was used to bond all brackets to the teeth.

Brackets Used: 120 Preadjusted Edgewise premolar stainless steel brackets with 022" x 028" slot were used in this study. (Roth Mini Twin brackets from Ortho Organizers)

Equipments used:

1. Tungsten Halogen curing unit- Hilux curing Light from Kulzer
2. Universal testing machine
3. Lawrence and Mayo Stereomicroscope
4. Air abrasion unit-NOVO Dual Blaster
5. Ultrasonic cleaning unit, Model- C-80-M, from Confident dental equipments, Bangalore
6. Green stone bur- Latch type
7. Micro torch
8. A custom made jig assembly to facilitate teeth to be subjected to shear bond strength on Universal testing machine.
9. Digital calipers- CD-6, Mitutoyo Corporation, Japan

Procedure

The sample for the study consisted of 120 extracted human premolar teeth. Immediately after extraction, the teeth were cleaned under running water to rid off any debris, blood stains etc and stored in 70% ethyl alcohol as reported in the literature. These teeth were then mounted on a cylindrical acrylic blocks exposing only the crown portion. Following which teeth were pumiced with non fluoridated pumice and rubber cup.

Bonding Procedure

A 37% phosphoric acid gel was applied to the buccal surface of tooth for 15 seconds. The teeth were then rinsed with a water spray for 30 seconds and dried with an oil free air source for 20 seconds until the buccal surfaces of the etched teeth appeared to be chalky white in color.

A thin coat of primer was applied on to the etched surfaces and the base of the brackets using a brush. The light cure adhesive was placed on each bracket base. The brackets were then properly positioned on the tooth using reverse tweezers with optimum pressure. Excessive adhesive was removed using a sharp scaler. In order to minimize the operative error, a single operator did the entire procedure of enamel preparation and bonding. Debonding was carried out using a Universal testing machine and the shear bond strength values were recorded. The residual adhesive on all the teeth were carefully removed from the enamel using a carbide finishing bur and micromotor at a low speed. Removal of adhesive was considered complete when no resin was apparent on visual inspection. After removing the resin with the bur, the enamel surfaces were not polished before etching.

Debonding was carried out using a Universal testing machine and the shear bond strength values were recorded. The residual adhesive on all the teeth were carefully removed from the enamel using a carbide finishing bur and micromotor at a low speed. Removal of adhesive was considered complete when no resin was apparent on visual inspection. After removing the resin with the bur, the enamel surfaces were not polished before etching.

Evaluation of Shear Bond Strength: Instron Universal Testing Machine (50 KN Hounsfield Tensometer, U.K) was used to measure the shear bond strength. This machine consists of two cross heads, upper and lower (Fig.4). The upper crosshead is movable, while the lower crosshead is stationary. The crossheads of the Instron are mounted on a hydraulic framework connected to a force recording unit. Progressive debonding force was applied to the brackets. The force required to debond the brackets from the enamel surface was recorded.

Shear bond strength of the brackets was measured 48hrs after bonding. The acrylic blocks were positioned in the lower crosshead with the crown portion of teeth facing upwards. The long axis of the tooth and the bracket base were parallel to the direction of the debonding force applied. A loop made of 0.8mm stainless steel wire was attached to the upper crosshead to apply shear force to debond the bracket. The loop portion was engaged below the gingival tie wing of the bracket.

A load cell with a range of 0-50 kg was used. The crosshead of the Instron moved at a uniform speed of 3mm/minute. The load was progressively increased till the bracket debonded from the tooth surface. The debonding force was measured in terms of Newton's. This was repeated for all the samples in the same order as they were bonded. The bond strength values obtained in terms of Newton's were converted into Megapascals using surface area of the bracket. The surface area of the bracket was determined by measuring the height and widths of the bracket base and applying the formula of a trapezium which is $\frac{1}{2}$ height X (sum of parallel sides) and the surface area of the brackets was obtained as 10.5mm². After debonding, the percentage of the surface of the bracket base covered by adhesive was determined using Stereomicroscope (Lawrence and Mayo) with Eye Piece of 10x magnifications (Fig. 3).

The percentage of the area still occupied by adhesive remaining on the tooth after debonding was obtained by subtracting the area of adhesive covering the bracket base from 100%. Later each tooth was assigned an adhesive remnant index (ARI) value according to Artun and Bergland.¹⁵

Score 0:	No adhesive left on the tooth
Score 1:	Less than $\frac{1}{2}$ of adhesive left on the tooth
Score 2:	More than $\frac{1}{2}$ of adhesive left on the tooth
Score 3:	All adhesive left on the tooth

The 120 debonded brackets were then divided into four groups containing 30 brackets on each group. The brackets in each group were then reconditioned using different techniques as follows.

Group 1: brackets were reconditioned by roughening the adhesive using a greenstone bur in a slow speed handpiece until most of the residue had been removed.

Group 2: brackets were reconditioned by direct flaming. Here, the flame tip of the gas torch flame was pointed at the bracket base for 5 seconds until the base became red hot, then quenched in water at room temperature and dried in an air stream.

Group 3: brackets were reconditioned by flaming followed by ultrasonic cleaning. Here, the flame tip of the gas torch flame was pointed at the bracket base for 5 seconds until the base became red hot, then quenched in water at room temperature and dried in an air stream. Brackets were then ultrasonically cleaned for 10 minutes.

Group 4: brackets were reconditioned by sandblasting. Here, sand blasting unit with 50 µm aluminium oxide abrasive powder was used. The distance between the bracket base and the handpiece head was fixed at 10 mm distance. Each bracket was sandblasted for 20-30 seconds under 5 bars (72.5 psi) line pressure.

After the brackets had been reconditioned, each bracket was bonded to the enamel surfaces that had been re-prepared for bonding, using the same method as for the new brackets. 48 hours after bonding, the brackets were debonded using universal testing machine and shear bond strengths were again recorded in MPa using the same method as for the new brackets. The debonded brackets were inspected under stereomicroscope, and the amount of adhesive remaining on the base scored using ARI index.

Results:

A sample of 120 brackets were tested for bond and rebond shear strength. Bonding and rebonding were carried out on the same teeth. The recycling method included were, grinding with green stone, direct flaming, sandblasting, and direct flaming followed by ultrasonic cleaning. The shear bond strength of new brackets acted as a baseline against which the bond strengths of reconditioned brackets could be measured.

(Graph 1)

Mean and standard deviation for new (control) and reconditioned brackets were calculated and recorded in table 1. Statistical analysis was performed using One way Analysis of Variance (ANOVA) test for comparison of five groups and recorded in table 2. Significance for all statistical tests was set at 5 % ($P \leq 0.05$). Adhesive Remnant index scores were recorded and tabulated in table 3.

Analysis of Variance (ANOVA) test was performed to find out if there was any statistically

significant difference between the mean shear bond strength values of five groups. The results of ANOVA test showed that there was a statistically significant difference ($P < 0.001$) in the mean shear bond strength values between the five groups.

Discussion

The goal of reconditioning of orthodontic brackets is to remove the bonding material from the bracket completely without damaging or weakening the delicate base or distorting the dimensions of the bracket slot.

The present study compared the shear bond strength of rebonded brackets that were reconditioned by four office reconditioning methods.

The mean shear peel bond strength of the new brackets (control) was 8.45 ± 2.2 MPa. Group 4 sample (sandblasting) showed the highest mean shear bond strength of 7.44 ± 0.9 MPa among the reconditioned methods tested followed by group 3 sample (flaming followed by ultrasonic cleaning) i.e. 6.00 ± 1.09 MPa, and group 2 (direct flaming) i.e. 5.46 ± 1.29 MPa. Group 1 sample (grinding with green stone) showed the lowest mean shear bond strength of 5.04 ± 2.21 MPa.

The optimal shear bond strength required for orthodontic clinical use is as yet unknown. Ideally, the brackets should be easily bonded to the enamel, not undergo any in service bond failures and yet be easily removed at the end of treatment without damage to the enamel surface¹⁶. Reynolds in 1975 gave 5.9 MPa to 7.8 MPa as the optimal range for bond strength required clinically¹⁷. The results of the present study indicates that the bond strengths of group 3 sample (reconditioned by direct flaming followed by ultrasonic cleaning) and group 4 sample (reconditioned by sand blasting) fall under optimal range for bond strength required clinically. The mean shear bond strength of Group 1 sample (grinding with green stone) is significantly lower than the control group (new brackets) and all other reconditioning methods. From a mechanical point of view, this is not surprising because preparing the brackets for rebonding by removal of the adhesive with a green stone, leaves a composite surface devoid of undercuts.

The results of this study agrees with Regan et al¹⁰, they compared the initial bond strength and rebond strength of metal brackets and found that, the initial bond strength were significantly greater than that of rebond strength. They used two methods to clean composite resin from the rebonded bracket bases- 1. green stone with a hand

piece at a low speed. 2. Bunsen flame for 3 seconds, followed by quenching in room temperature water, air abrasion for 5 seconds and finally electropolishing. The fall in the rebond strength can be explained by examining the bracket bases under the scanning electron



Fig. 1. Brackets bonded to teeth mounted in acrylic blocks. Acrylic blocks color coded to differentiate the four reconditioning groups.



Fig. 2. Hounsfield Tensometer, (U.K)



Fig. 3. Lawrence and Mayo Stereomicroscope used to evaluate the adhesive remaining on the tooth



Fig. 4. Microtorch



Fig. 5. Ultrasonic cleaning unit, Model- C-80-M, from Confident dental equipments, Bangalore



Fig. 6. Air abrasion unit- NOVO Dual Blaster

microscope. The foil mesh brackets prepared with the green stone revealed a flat composite surface obliterating the entire mesh thus eliminating virtually all mechanical retention. Wright and Powers¹ in their study subjected the brackets to be recycled to a very harsh treatment such as, use of green stone either to remove the adhesive from the base or grinding the mesh base itself. The mesh base or any kind of base plays a major role in determining the bond strength of the bracket because the bond achieved between the enamel and the bracket is through mechanical interlocking of the adhesive to resin tags produced in the enamel by virtue of acid etching and between bracket and resin surface by

means of the characteristic base design. It is a must, in any recycling process to maintain the integrity of the surface design of the bracket base. By using green stone either to grind of the adhesive from the base or by grinding the mesh base itself resulted in a serious damage to the base which left no potential mechanical retention available for rebonding resulted in a decrease in bond strength.

Basudan A. M. and AL Emran¹⁸ also reported a significant reduction in the bracket bond strength after grinding the adhesive with a green stone to the surface of the mesh base.

Table 1. comparison of shear bond strength between groups

Group	Mean-Bond strength(MPa)	Std. Dev.	Standard Error	CV (%)
Control	8.4460	2.2108	0.2018	26.1760
Group 1	5.0458	1.1695	0.2135	23.1786
Group 2	5.4637	1.2962	0.2367	23.7247
Group 3	6.0045	1.0966	0.2002	18.2631
Group 4	7.4463	0.8870	0.1619	11.9119

Table 2. Comparison of five groups (Control, I, II, III, and IV) by one-way Analysis of variance (ANOVA) test

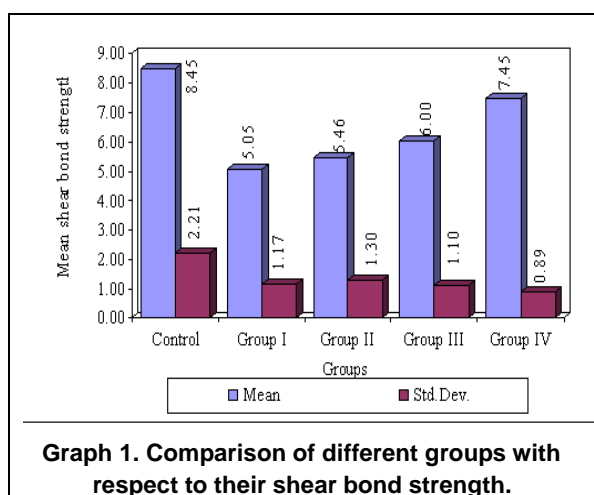
SV	DF	SS	MSS	F-value	P-value	Significance
Between Groups	4	460.57	115.14	37.1829	0.0000	Highly significant.
Within groups	235	727.72	3.10			
Total	239	1188.29				

Significant at 5% level of significance (P<0.05)

Table No. 3: Adhesive Remnant Index Scores

Value	criteria	control	Group 1	Group 2	Group 3	Group 4
0	No adhesive left on tooth	12	3	2	2	3
1	Less than half of adhesive left on tooth	18	5	4	4	2
2	More than half of adhesive left on tooth	69	17	20	19	20
3	All adhesive left on tooth	21	5	4	5	5

In contrast to the results of our study, Eagan et al¹⁹ reported no significant difference between shear bond strength of new brackets and brackets reconditioned by roughening of debonded bracket base with green stone. Even though they used green stone to prepare the surface of debonded brackets, took care not to expose the metal surface and reported that the rebond strength when bonded with paste-paste adhesive system produced bond strength indistinguishable from initial bond strength. They recommended that bracket preparation protocol for rebonding should include roughening of residual resin and use of paste-paste adhesive system.



The mean shear bond strength of Group 2 sample (Flaming) was slightly more than the Group I, but still it is significantly lower than new brackets and brackets reconditioned by flaming followed by ultrasonic cleaning and sandblasting. This is understandable because, the mechanical retentive areas were obstructed by char. Buchman¹² found that heat has direct effect on hardness and tensile bond strength of metal brackets. In his study he found that recycling process used by Esmadent company which employed heat had small decrease in the hardness and tensile strength and showed minimal carbide separation. This alteration in metal structure is very minimal and the decrease in hardness is not much of clinical significance. In the same study it was found that very high heat such as flame even with decreased exposure time caused significant carbide separation.

The disadvantage of burning off the composite is that the bracket discolours, unless it is electropolished afterwards. Furthermore, the metal is softened by the heating process, and is

thus more vulnerable to masticatory damage. The composite incineration process is known to produce toxic fumes that might be inhaled.¹⁹ Nevertheless, the amount of adhesive remnants burned during the in-office bracket reconditioning process is small and with wearing a facemask in an open room space, the produced vapour is considered as a very low hazardous material.

This study examined the effect of ultrasonic cleaning flamed brackets in an attempt to dislodge residual char. Andrew N. Quick et al reported in their study that, flamed, ultrasonically cleaned brackets had a significantly lower bond strength than new brackets and indicated that ultrasonically cleaning for 5 minutes was insufficient to dislodge the residue. Hence, in the present study increased the procedure of ultrasonic cleaning for 10 minutes. The results of the bond strength tests of the present study showed that flamed, ultrasonically cleaned brackets had slightly higher bond strength (6 MPa) than compared to Group I and II but still significantly lower bond strength than new brackets. This indicates that, either flaming for 10 seconds was insufficient to combust all the composite, or that ultrasonically cleaning for 10 minutes was insufficient to dislodge the residue.

This study used air abrasion as a part of reconditioning process. The mean shear bond strength of Group 4 sample (sandblasting) showed the highest shear bond strength (7.44 MPa) among four reconditioning methods tested, but still is significantly differ from the control. This agrees with Regan et al¹⁰, who reported a significant reduction in bond strength by as much as 41.4% following sandblasting.

Grabouski²⁰ et al found no significant difference between new, new etched, and rebounded. Their findings support the use of air abrasion to prepare the base surface of an accidentally debonded bracket. Demas²¹ et al compared the bond strength of rebounded brackets subjected to air abrasion for 3 seconds, 10 seconds, flame and air abrasion for 3 seconds and bracket treated with green stone and scaler. They found that the rebond tensile and shear strength of all brackets cleaned with technique involving air abrasion were significantly greater than that of new brackets. Sonis¹³ compared the shear bond strengths of previously failed bonded metal brackets subjected to air abrasion was compared with new brackets and found no significant differences between the two groups. In the

present study, group 4 sample (sandblasting) showed the highest shear bond strength among the reconditioning methods tested and the bond strength is within the range of optimal bond strength. This study indicates that the mesh base of brackets is sufficiently resilient to withstand sandblasting. The results of the Adhesive Remnant Index (ARI) indicated that in the majority of cases the amount of adhesive was in the category of 2 i.e. more than ½ of adhesive left on the tooth. This illustrates that bonding between the adhesive and the tooth surface was adequate and that the primary failure site during the debonding process occurred at the base-adhesive interface.

The present study was mainly concerned with the bond strength of reconditioned brackets. The effects of reconditioning on the corrosion susceptibility of the reconditioned metal brackets have to be considered in detail. Further studies may be undertaken to evaluate the same. As with any in-vitro study caution must be exercised when attempting to extrapolate results to the clinical settings.

CONCLUSION

Office reconditioning of stainless steel metal brackets by grinding with green stone and direct flaming showed significantly lower shear bond strengths. Office reconditioning of stainless steel metal brackets by sandblasting method showed the highest bond strength among the reconditioning methods tested. This study confirms sandblasting as the simplest, most efficient manner of immediately recycling debonded brackets.

References:

1. Wright W.J. and Powers J.M. In vitro tensile bond strength of reconditioned brackets. *Am. J. Orthod.* 1985; 87: 247-52. doi:10.1016/0002-9416(85)90046-6
2. Postlethwaite K.M. Recycling bands and brackets. *British Journal of Orthodontics* 1992; 19: 157-64. PMID:1627528
3. Matasa C.G. Pros and cons of the reuse of direct bonded appliances. *Am. J. Orthod Dentofacial Orthop.* 1989; 96: 72-76. doi:10.1016/0889-5406(89)90232-1
4. Unkel T. Recycling orthodontic products. *J. Clin Orthod.* 1987; 21: 871-72.
5. Mascia V.E. and Chen S. Shearing strengths of recycled direct bonding brackets. *Am. J. Orthod.* 1982; 82: 211-216. doi:10.1016/0002-9416(82)90141-5
6. Wheeler J.J. and Ackerman J.R. Bond strength of thermally recycled metal brackets. *Am. J. Orthod.* 1983; 83: 181-186. doi:10.1016/0002-9416(83)90081-7
7. Di Pasquale T.J. Reconditioning and reuse of orthodontic devices. *Am. J. Orthod Dentofacial Orthop.* 1992a; 102: 187-189. doi:10.1016/S0889-5406(05)81229-6
8. Di Pasquale T.J. Reconditioning and reuse of orthodontic devices. *Am. J. Orthod Dentofacial Orthop.* 1992b; 102: 285-87. doi:10.1016/S0889-5406(05)81065-0
9. Majjer R. and Smith D.C. Biodegradation of the orthodontic bracket system. *Am. J. Orthod Dentofacial Orthop.* 1986; 90: 195-98. doi:10.1016/0889-5406(86)90065-X
10. Regan D., LeMasney B., Van Noort R. the tensile bond strength of new and rebounded stainless steel orthodontic brackets. *European Journal of Orthodontics* 1993; 15: 125-35. PMID:8500538
11. Davidson C.L., Duysters P.P.E., De Lange C, Bausch J.R. Structural changes in composite surface material after dry polishing. *Journal of Oral Rehabilitation* 1981; 8: 431-39. doi:10.1111/j.1365-2842.1981.tb00517.x PMID:6457903
12. Buchman D.J.L. Effects of recycling on metallic direct bond orthodontic brackets. *Am. J. Orthod.* 1980; 77: 654-68. doi:10.1016/0002-9416(80)90157-8
13. Sonis A. Air abrasion of failed bonded metal brackets: a study of shear bond strength and surface characteristics as determined by scanning electron microscopy. *Am. J. Orthod Dentofacial Orthop.* 1996; 110: 96-98. doi:10.1016/S0889-5406(96)70094-X
14. Tavares SW, Consani S, Nouer DF, Magnani MB, Nouer PR, Martins LM. Shear bond strength of new and recycled brackets to enamel. *Braz Dent J.* 2006; 17(1):44-48. doi:10.1590/S0103-64402006000100010 PMID:16721464
15. Smith N.R. and Reynolds I.R. A comparison of three bracket bases: An invitro study. *British Journal of Orthodontics* 1991; 18: 29-35. PMID:1827348
16. Artun J., and Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid etch enamel pretreatment. *Am. J. Orthod Dentofacial Orthop.* 1984;85: 333-40.
17. Ireland A.J., and Sheriff M. The effect of timing of archwire placement on in vitro bond failure. *British Journal of Orthodontics.* 1997;24: 243-54. doi:10.1093/ortho/24.3.243
18. Basudan AM, Al-Emran SE. The effects of in-office reconditioning on the morphology of slots and bases of stainless steel brackets and on the shear/peel bond strength. *Journal of Orthodontics* 2001; 28(3):231-36. doi:10.1093/ortho/28.3.231 PMID:11504901
19. Egan F.R., Alexander S.A., Cartright G.E. Bond strength of rebounded orthodontic brackets. *Am. J. Orthod Dentofacial Orthop.* 1996; 109: 64-70. doi:10.1016/S0889-5406(96)70164-6
20. Grabouski J.K., Staley R.N., Jakobsen JR. The effect of microetching on the bond strength of metal brackets when bonded to previously bonded teeth: an in-vitro study. *Am. J. Orthod Dentofacial Orthop.* 1998; 113: 452-60. doi:10.1016/S0889-5406(98)70192-1
21. Klaasen C.D. *The Basic Science of Poisons*, 5th edition, 24,737-71.

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