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Comparison of Shear Bond Strength of Bonded and Rebonded Orthodontic Brackets Following Removal of Adhesive Remnants by Four Different Methods

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Abstract

Aim: The aim of the in vitro study was to examine the enamel surface after the application of four different methods for adhesive removal following the bracket debonding procedure, as well as to compare their effects on enamel surface.
Methods: Premolars (n=60) were randomly assigned to four groups. After initial debonding and recording the shear bond strength (SBS), adhesive remnant index (ARI) scores were assessed. The removal method for each of the four groups was the use of 1) a round bur, 2) rubber wheel bur, 3)12 fluted tungsten carbide bur, and 4) scaler. After that, teeth in all four groups were kept in artificial saliva for one month. After rebonding with a new bracket, again the SBS and ARI scores were measured. Two representative samples from each group were examined under a scanning electron microscope. ……. P-value <0.05 was considered as significant. ANOVA test was used to assess the SBS association within the group. Paired T test was used to assess the SBS between the group. fisher's exact test was performed to compare ARI index before and after.
Results: There was significant decrease in secondary SBS value in group 1 but significant increase in secondary SBS value in group 3, and a slight decrease in SBS value in group 4. In SEM images, there were composite remnants in all the four groups with fewer remnants in group 2. Enamel surface damage was observed in the SEM image of group 3. ARI scores showed no significant difference.
Conclusion: Adhesive remnant removal efficiency of the round bur and scaler are less. Rubber wheel bur is a good choice of instrument for removal of adhesive remnants from tooth surface as it does not affect the bond strength. Tungsten carbide bur shows good results, as secondary bonding SBS value increased. Significant difference between ARI scores did not exist, indicating a higher number of mixed type failure in all groups.

Keywords: ARI, SEM, Shear Bond Strength

1. Background

Bracket debonding due to inappropriate occlusal forces, or intentional removal of brackets to reposition them to achieve ideal tooth position are very common occurrences for orthodontists during treatment. According to Lovius et al. debonding of brackets occurs in 16-23% of orthodontic patients, therefore several teeth have to be rebonded routinely in daily orthodontic practices (1). The effect of repeated bonding on the same enamel surface has been investigated by many authors and the results are inconsistent (2, 3), Some studies showed that there was no significant difference between SBS of fresh and rebonded surfaces, while others reported increased, decreased, and inconsistent results in SBS after the second bonding of enamel surfaces 1.

The residual resin left behind after bracket debonding must be cleaned efficiently and rapidly while preserving enamel surface; in addition, enamel surface must be smoothed and polished to prevent plaque accumulation (3)

Several factors are involved in these procedures, including the tools used for debonding, protocols for residual resin removal, the type of adhesive used, and the operator's skill. So far, different modalities have been used to remove adhesive remnants after debonding including hand instruments (scalers), various burs, ultrasonic devices, and air abrasion units (4).

The aim of the in vitro study was to examine the enamel surface after the application of four different methods for adhesive removal following the bracket debonding procedure, as well as to compare their effects on enamel surface.

2. Methods

Freshly extracted 60 premolars teeth from patients undergoing orthodontic extractions in the Department of Oral and Maxillofacial Surgery, Narsinhbhai Patel Dental College and Hospital, Visnagar, India were collected and stored immediately in 0.1% thymol solution. These teeth were randomly divided into four groups of 15 teeth. All the teeth were mounted on self-polymerizing acrylic blocks, with the crowns exposed and roots embedded in acrylic. Then the teeth were etched for 30 sec with 37% phosphoric acid, rinsed for 15 seconds and then dried with an oil-free air spray. A thin layer of transbond XT primer (3m Unitek, Monrovia, California, USA) was applied on the enamel surface. Premolar stainless steel brackets (0.022 MBT AO Mini Master sheboygan,USA) were then bond with Transbond XT adhesive (3m Unitek) and cured for 12 sec (3 sec on each side of the bracket). Teeth were kept in deionized water for 24 hours at 37°C.

The shear bond strength test was performed using a universal testing machine (model no: 5982, Instron Co, INDIA.) using a crosshead speed of 1.0 mm/min, the SBS value was recorded in Newton (then converted into MPa by dividing the measured value by the bracket surface area 9 mm²).

After deboning, the teeth were examined by stereomicroscope with 4x magnification and the adhesive remnant index (ARI) scores were assessed regarding the remnant resin material on the enamel surface, as defined by Artun and Bergland. The ARI scores are as such:

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.

After primary debonding, composite remnants in the experimental groups were remove from the enamel surfaces of the teeth by different rotary instruments without water, as follows:

Group 1: Residual composite removal by round bur

Group 2: Residual composite removal by rubber wheel bur

Group 3: Residual composite removal by tungsten carbide bur

Group 4: Residual composite removal by scaler

Teeth were immersed in artificial saliva for one month at 37°C. After adhesive removal, two samples from each group were scanned by a scanning electron microscope. Rebonding was done using new brackets in all groups, with the same procedure detailed in the primary group. Teeth were kept in deionized water for 24 hours at 37°C. Then SBS and ARI scores were measured again, as described previously.

Statistical Analysis

Frequencies and percentages for categorical data were computed. A standard statistical software package (SPSS, version 20.0) was used. For normality, the Shapiro-Wilk test was performed. ANOVA test was used to assess the SBS association within the group. Paired t-test was used to assess the SBS between the groups. Fisher's exact test was performed to compare the ARI scores before and after. The level of significance was set at $P \leq 0.05$.

3. Results

The results of the ANOVA test demonstrated no significant difference in the mean SBS of the four groups after primary debonding ($P>0.5$) (Table 1). However, the results of the ANOVA test demonstrated that significant difference existed in the mean SBS of the four groups after secondary debonding ($P<0.5$) (Table 2). Table 3 showed showed no statistically significant difference between primary bonding and secondary bonding with respect to group 2 (rubber wheel bur). There was statistically

Table 1. Primary bonding shear bond strength value (MPa)

Group	Primary Bonding
Group 1 (n = 15) (round bur)	9.00 ± 0.5618
Group 2 (n = 15) (rubber wheel bur)	8.86 ± 0.4908
Group 3 (n = 15) (tungsten carbide bur)	9.00 ± 0.5580
Group 4 (n = 15) (scaler)	9.00 ± 0.5694
ANOVA Test	p =0.880 (Not Significant)

Table 2. Secondary bonding shear bond strength value

Group	Secondary bonding(mean ±SD)
Group 1 (n=15) (round bur)	6.65 ± 0.3500
Group 2 (n=15) (rubber wheel bur)	9.00 ± 0.4208
Group 3 (n=15) (tungsten carbide bur)	9.70 ± 0.1533
Group 4 (n=15) (scaler)	7.92 ± 0.6041
ANOVA Test	p = 0.001 (significant)

significant difference in primary bonding (SBS) and secondary bonding (SBS) with respect to group 1 (round bur), group 3 (TC bur), and group 4 (scaler). Statistically significant difference existed in primary bonding (SBS) and secondary bonding (SBS) with respect to group 1(p (0.000)), and the primary bonding group (SBS) was higher than the secondary bonding (SBS) group 1 by 2.3500 (95%, CI: 1.9897, 2.7102). There was statistically significant difference in primary bonding (SBS) and secondary bonding (SBS) with respect to group 3 (p (0.001), and primary bonding (SBS) in group 3 was lower than secondary bonding (SBS) in group 3 by 0.7066 (95%, CI: -1.0546, -0.3586). Statistically significant difference existed in primary bonding (SBS) and secondary bonding (SBS) with respect to group 4 (t5.639, p (0.000) < 0.05), and primary bonding (SBS) in group 4 was higher than secondary bonding (SBS) in group 4 by 1.0733 (95%, CI: 0.6650, 1.4816).

Fisher's exact test showed no significant difference after primary debonding ARI (p>0.5) (Table 4) and after secondary debonding ARI (p>0.5) (Table 5). SEM evaluation was done under 2000x magnification (surface topography imaginning of tooth surface in ×2000 magnification) and the SEM image of group 2(Fig 4) revealed a smaller number of adhesive islands.

Table 3. Paired sample t test for primary and secondary shear bond strength (mean ± SD)

Group	Primary Bonding	Secondary Bonding	P value	Significance
Group 1 (n = 15) (95%, CI: 1.9897, 2.7102)	9.00 ± 0.5618	6.65 ± 0.3500	0.000	< 0.05 (Significant)
Group 2 (n = 15) (95%, CI: 1.9897, 2.7102)	8.86 ± 0.4908	9.00 ± 0.4208	0.497	> 0.05 (Not Significant)
Group 3 (n = 15) (95%, CI: - 1.0546, -0.3586)	9.00 ± 0.5580	9.70 ± 0.1533	0.001	< 0.05 (Significant)
Group 4 (n = 15) (95%, CI: 0.6650, 1.4816)	9.00 ± 0.5694	7.92 ± 0.6041	0.000	< 0.05 (Significant)

Table 4. Primary debonding (ARI)

Group	Primary debonding (ARI)				Total
	0.0	1.00	2.00	3.00	
Group 1 (Round Bur)	0	7	6	2	15
Group 2 (Rubber Wheel Bur)	0	4	8	3	15
Group 3 (Tungsten CarbideBur)	1	7	6	1	15
Group 4 (Scaler)	0	9	5	1	15
Total	1	27	25	7	60

Fisher's Exact Test p = 0.689 (Not Significant)

Table 5. Secondary debonding (ARI)

Group	Secondary debonding (ARI)				Total
	0.0	1.00	2.00	3.00	
Group 1 (Round Bur)	2	9	3	1	15
Group 2 (Rubber Wheel Bur)	0	7	7	1	15
Group 3 (Tungsten CarbideBur)	1	5	8	1	15
Group 4 (Scaler)	0	11	4	0	15
Total	3	32	22	3	60
Fisher's Exact Test p = 0.240 (Not Significant)					

compare to the other groups. Scanning electron microsope image of group 3 (Fig 1) revealed very a smaller number of adhesive remnants, but also showed enamel surface cracks. SEM image of groups 1 (Fig 2) and 4 (Fig 3) revealed a considerable number of adhesive islands.

4. Discussion

Bonding and debonding protocols have become easier due to direct bracket bonding on enamel surfaces (5), However, the goal of post-orthodontic treatment is to restore the original topographic conditions (6, 7) if irreversible iatrogenic lesions were caused (5.4%) (8), as a result of the treatment due to various factors, as reported in the literature (9, 10), other damaging effects, which are inevitable are adhesive remnants and damages to the enamel structure (11, 12)

Several techniques for cleaning the tooth surface have been described. To observe the cleaning results of these four methods, SBS, ARI scores, and scanning electron microscopy (SEM) was done. The burs and abrasive (fluted tungsten carbide burs, round bur, rubber wheel bur, and ultrasonic scaler) selected for the study was according to the protocols commonly used by orthodontists, (12). SEM This could indicate that this instrument was ineffective in composite elimination after debonding, although its preferred by some dentists as “a tool for composite removal without abrading the enamel surface” (13),

In the SEM evaluation, adhesive remnants were shown to nest on the enamel surface although the surface was cleaned with round burs, reducing the enamel coarseness and bond strength. Significant differences did not exist between the primary and secondary debondings in group 2, where the rubber wheel bur was used. The rubber wheel bur was time consuming although it showed satisfactory outcomes in the SBS measurements and SEM evaluations.

There was statistical significant difference between primary and secondary debondings in group 3 when the tungsten carbide bur was employed to extricate the leftover adhesive. The secondary SBS value slightly increased compared to primary SBS. This indicate that this tool is useful to remove adhesive remnants, but SEM (scanning electron microscope) images suggested that plenty of enamel damage had occurred.

Eminkahyagil et (14) al 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 hand pieces. Pignatta et al (15). concluded that a tungsten carbide bur caused several scratches on the enamel surface, which were not observable after polishing.

Zachrisson and Arthun (16), Van Waes et al. (17), and Hosein et al (18) reasoned that low speed TC burs produced the finest scratches, with nominal enamel loss. Similarly, Campbell (19) considered this method efficient although generally awkward for clinicians. Moreover, the ranking of bonding strength in dental adhesives appears to be test-dependent, with micro tensile bond test appearing to have greater accurate in differentiating among stronger adhesives.

In group 4, a scaler was employed to extricate the leftover adhesive, secondary SBS value decreased compared to primary SBS. The results could indicate that this tool was incompetent in composite removal after debonding.

The ARI scores were not significantly different among groups following primary and secondary debondings, denoting a greater number of mixed type failures in all groups. Clinically, the preferred failure site is between the adhesive and bracket due to possible enamel fractures as a result of adhesive enamel failures. One of the concerns in orthodontic practice is also enamel loss during pumice prophylaxis, etching, debonding, and adhesive removal procedures (20)

SEM images were taken under 2000x magnification for each specimen. Significant differences were found among different tested methods. The rubber wheel bur, round bur, and scaler did not affect enamel surfaces, whereas the tungsten carbide bur showed significant amount of enamel surface cracks. Also, there was a significant number of composite remnants in all the groups except when the rubber wheel bur was used. In the rubber wheel bur group, very little amount of adhesive remnants was seen.

Conclusion

Within this in vitro study we came to the following conclusions:

Round bur could not be recommended for adhesive remnant removal as it caused significantly lower rebonding strength; also in SEM images there were adhesive remnants on the tooth surface after cleaning.

A rubber wheel bur showed comparable bond strength before and after. Also, SEM image showed a smaller number of adhesive remnants, so this could be recommended for adhesive remnant removal; the only drawback is that it is quite time consuming.

The use of the tungsten carbide bur caused a significant increase in SBS values but it could be recommended to be used on low speed as it caused enamel roughness that was evident on the SEM image. The use of an ultrasonic scaler caused decreased bond strength and left a significant number of adhesive remnants on the tooth surface as was seen in SEM images. Hence, this method could not be recommended. ARI scores showed no significant difference after primary and secondary debonding, denoting a greater number of mixed type failures in all groups.

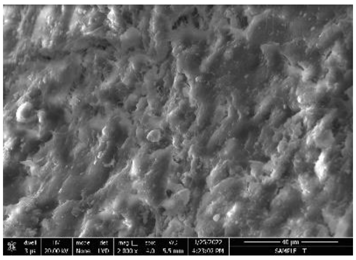

Figure 1. SEM image of enamel after adhesive removal by a 12 fluted tungsten carbide bur

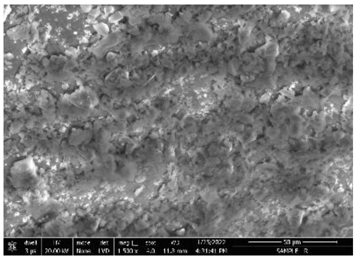

Figure 2. SEM image of enamel after adhesive removal by a round bur

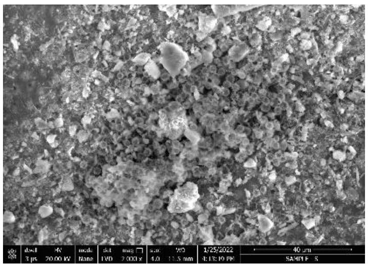

Figure 3. SEM image of enamel after adhesive removal by a scaler

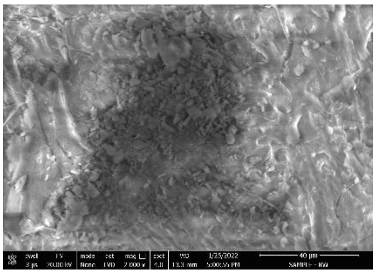

Figure 4. SEM image of enamel after adhesive removal by a rubber wheel bur

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