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Dentistry Section

SBS vs Inhouse Recycling Methods-An Invitro Evaluation

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ABSTRACT

Introduction: In today's world of economic crisis it is not feasible for an orthodontist to replace each and every debonded bracket with a new bracket- quest for an alternative thrives Orthodontist. The concept of recycling bracket for its reuse has evolved over a period of time. Orthodontist can send the brackets to various commercial recycling companies for recycling, but it's impractical as these are complex procedures and require time and usage of a new bracket would seem more feasible. Thereby, in-house methods have been developed. The aim of the study was to determine the SBS (Shear Bond Strength) and to compare, evaluate the efficiency of in house recycling methods with that of the SBS of new brackets.

Materials and Methods: Five in–house-recycling procedures-Adhesive Grinding Method, Sandblasting Method, Thermal Flaming Method, Buchman method and Acid Bath Method were used in the present study. Initial part of the study included the use of UV/Vis spectrophotometer where in the absorption level of base of new stainless steel bracket is compared with the base of a recycled bracket. The difference seen in the UV absorbance can be attributed to the presence of adhesive remnant. For each recycling procedure the difference in UV absorption is calculated. New stainless steel brackets and recycled brackets were tested for its shear bond strength with Instron testing machine. Comparisons were made between shear bond strength of new brackets with that of recycled brackets. The last part of the study involved correlating the findings of UV/Vis spectrophotometer with the shear bond strength for each recycling procedure.

Results: Among the recycled brackets the Sandblasting technique showed the highest shear bond strength (19.789MPa) and the least was shown by the Adhesive Grinding method (13.809MPa).

Conclusion: The study concludes that sand blasting can be an effective choice among the 5 in house methods of recycling methods.

Keywords: In House Recycling methods, Shear bond strength, UV/Vis spectrophotometer

INTRODUCTION

The direct bonding of orthodontic attachments to etched enamel surfaces with dental resins has become an accepted clinical procedure in orthodontics since its introduction by Buoncore [1] in 1955. There are many factors that can potentially affect the bond strength between the enamel and the orthodontic bracket including: the type of enamel conditioner, acid concentration, length of etching time, composition of the adhesive, bracket base design, the bracket material, the oral environment as well as the skill of the clinician. The shear bond strength of attachments indicates the retentive strength of the bracket on the tooth and should be sufficient to withstand forces of mastication and stress from arch wires and other force delivery system.

The medical profession has reused its metal instruments since the very beginning. However, the current reuse of direct bonded appliances has met with resistance, which is related neither to the nature of the materials used, nor to the lack of sterilization procedures. The real reasons lie not only in the possible alterations caused both by wear and reprocessing, but also in the mind of the practitioner. The risk of infection or cross-contamination, which may linger in the minds of patient's as well as the clinician, does not arise as the brackets are used for the same patient after being recycled by the various methods. It is significant; however, that in today's society, perceptions have changed and recycling, now, is a part and parcel of regular orthodontic practice [2].

Clinicians are very much concerned about how to best deal with the unintentional/ intentional debonded brackets. One practical solution is recycling and reuses them for the same patient during the same visit. The process of bracket recycling has emerged concurrently with the practice of direct bonding. This is essential, as new brackets cannot be used all the time to replace broken brackets. Once a bracket is recycled for its use again, it should exhibit sufficient bond strength. Although literature have shown the presence of residual debris on the base of recycled bracket, no study had been done to quantify the amount of residual debris present on the base of the recycled bracket nor is there any substantial literature on the influence of residual debris on the bond strength of recycled brackets [2,3].

Investigators have compared initial bond strengths with rebond strengths and reached differing conclusions regarding the various recycling methods. It has been shown that shear bond strength values between 5.9 and 7.8 MPa are required for clinical usage [4]. However, there has been no consensus on how the rebond strength compares with the initial bond strength. There have been differing opinions regarding the difference in bond strength, which can be attributed to the recycling process itself.

In the present study quantification of residual debris on the bracket base after recycling, the bases of brackets were subjected to UV/Vis spectroscopy. The instrument used in ultraviolet-visible spectroscopy is called a UV/Vis spectrophotometer. It measures the absorbance of bracket base before and after recycling; and any difference seen in the absorbance of bracket base implicates the presence of residual debris. Thus, indirect quantification of the amount of residual debris including remnant adhesive present on the base of a recycled bracket by UV/Vis Spectrophotometer enables us to test the efficiency of different recycling procedures.

MATERIALS AND METHODS

The present invitro study was planned and done in Saveetha Dental College and Hospital, Chennai in 2010. A total of 220 extracted lower premolar teeth and 220 pre-adjusted edgewise lower premolar stainless steel brackets (Gemini, 3M Unitek, Monrovia, California), Sandblasting Machine (Danville Engineering, Danville, California), Electro polishing Unit, UV/Vis Spectrophotometer, (Model 500, Varian Cary, Palo Alto, California), Instron Universal Testing Machine (Model 4501, Canton, MA) were used in the study to evaluate the effectiveness of the recycled brackets for their SBS. Two hundred and twenty premolar teeth were divided into 6 groups (Group I –VI) and mounted on coloured acrylic blocks with only the crown portion exposed [Table/Fig-1]. The bonding procedure was performed as suggested by the manufacturer using Transbond XT adhesive (3M Unitek).

The 100 'TEST' brackets bonded to teeth belonging to the subgroup B1 were then debonded using a debonding plier, with no distortion of the bracket base. Following which the different recycling methods were carried for the 'TEST'brackets belonging to groups numbering II, III, IV, V and VI [Table/Fig-2]. The flowchart for methodology is given [Table/Fig-3].

Recycling Methods

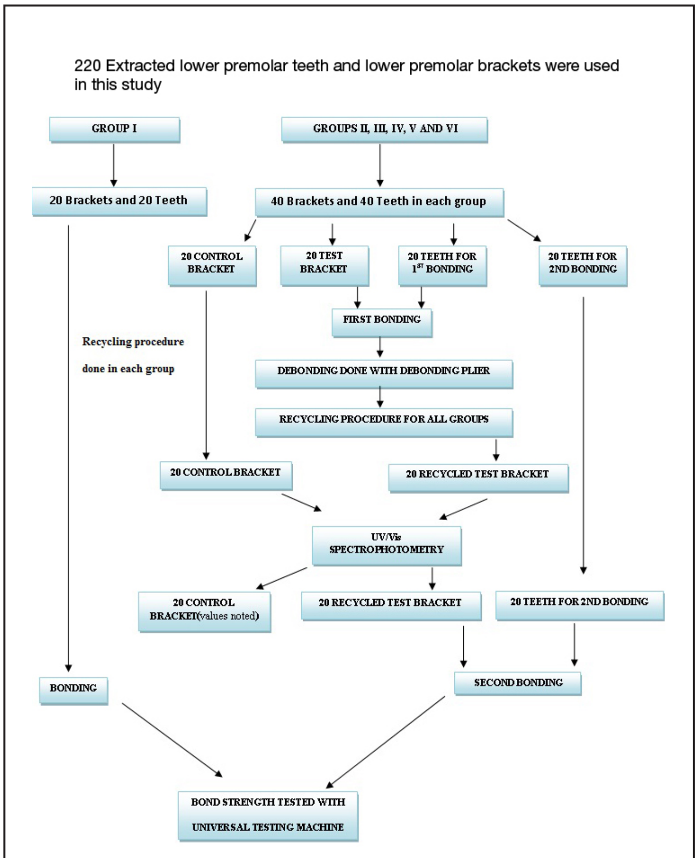
Group II: Grinding Method [5-7]- Grinding of the bracket base was done using a green stone operated on a straight slow speed hand piece at a speed of 25,000 revolutions/min for approximately 25 sec. Care was taken during grinding not to expose and damage the metal mesh.

Group III: Sandblasting Method [5-7]- Sandblasting with 50 µm Aluminum oxide particle powder was done from a distance of 10mm away from the nozzle of the micro etcher under air pressure of 90 PSI until bonding resin was no longer visible to naked eye and bracket base appears frosted. After sandblasting they were dried in compressed air.

[Table/Fig-1]: Pre molar brackets mounted on colour-coded acrylic blocks (Group I-VI)

Groups	Colour coding acrylic blocks	Recycling procedure	No of stainless steel brackets		No of extracted premolar teeth	
Group I	White	New brackets	20 (Group A)		20 (Group B)	
			Control	Test	1st Bonding (B1)	2nd Bonding (B2)
Group II	Brown	Adhesive Grinding	20	20	20	20
Group III	Blue	Sandblasting	20	20	20	20
Group IV	Yellow	Thermal flaming	20	20	20	20
Group V	Red	Buchman	20	20	20	20
Group VI	Green	Acid bath	20	20	20	20

[Table/Fig-2]: Sample size, Distribution of teeth and brackets into 6 groups



[Table/Fig-3]: Flow chart of the methodology

Group	Mean ±SD	Minimum	Maximum
Group I	20.929±3.608	16.180	28.620
Group II	13.809±0.685	12.240	14.980
Group III	19.798±2.028	17.050	25.340
Group IV	18.851±1.329	16.790	21.480
Group V	18.607±2.027	14.790	22.480
Group VI	19.134±2.073	16.150	23.890

[Table/Fig-4]: Comparison of shear bond strengths between the 6 groups

Group IV: Direct flaming Method [5-7]- The brackets are held with a bracket holding tweezers and the base of the bracket is heated with the help of micro torch, using the non luminous zone of the flame until the debonded bracket becomes cherry red in order to burn off the residual resin from the base. Then the bracket was immediately quenched in water and dried in an air stream.

Group V: Buchman Method [5-7]- A Bunsen flame was directed at the bracket base for a few seconds (5–10) until the bonding agent started to ignite and burn and then quenched in water at room temperature. Then a sand blaster with Aluminum oxide particles was used to sand blast the bracket for 5 sec. The pressure and the distance between the nozzle tip of the sand blaster and the bracket base were fixed. The next step was to electro polish the bracket using an electro-polishing unit

Group VI: Acid bath Method [5-7]- In this method the adhesive has been burned off with the help of a micro torch, the next step was to submerge the bracket for 5-15 seconds in a solution of 32% hydrochloric acid and 55% nitric acid, mixed in a 1:4 ratio. This process rapidly removes any tarnish, dissolves any adhesive residue and it also has a disinfectant effect.

The base of recycled 100 test brackets belonging to groups II, III, IV, V&VI were evaluated by UV/Vis transmittance analysis. Diffuse light transmittance measurements were performed in 300-600nm wavelengths. Data was recorded with a computer connected to spectrophotometer.

As the different recycling procedures involved the exposure of the bracket to various conditions, it was decided to expose the new brackets to respective recycling procedures without the adhesive present on the bracket base. For this purpose 80 new brackets belonging to the subgroup 'CONTROL'in groups III, IV, V and VI were used. The 'CONTROL'brackets belonging to group II were not subjected to grinding recycling procedure as there was no chemical / thermal exposure of the bracket in this method. Heat generated during the grinding procedure was controlled by constant irrigation with water.

Then the 'CONTROL'bracket for Groups II to VI was subjected to UV/Vis spectrophotometer, degree of absorption obtained, would act as 'CONTROL'. Degree of absorption of recycled 'TEST' brackets base belonging to the groups II, III, IV, V and VI was also estimated and any difference seen in the absorption levels was attributed to the presence of residual debris present on the bracket base. This indirectly quantified the residual debris present on the base of the recycled 'TEST'brackets belonging to the groups II, III, IV, V and VI.

Rebonding of Recycled brackets

The 100 recycled 'TEST'brackets belonging to Group II, III, IV, V and VI respectively are then bonded again to the remaining 100 mounted teeth belonging to the subgroup B2 of groups II, III, IV, V and VI. 20 new brackets belonging to group I was also bonded to the 20 mounted teeth belonging to group I. Bonding was done in the same way as explained before. These 120 bonded teeth were then incubated in artificial saliva for 24 hours at 37°c prior to testing. Shearing tests were performed with the Universal Testing Machine at the crosshead speed of 0.5 mm per minute. The load required for debonding each recycled bracket was recorded.

RESULTS

All the recycled brackets belonging to the different groups had produced shear bond strengths higher than those recommended by Reynolds's for clinical usage. Results shows that the Sandblasting technique had the highest recycled shear bond strength (19.7MPa), which was followed by Acid Bath method (19.1MPa), Direct Flaming Method (18.8MPa) and Buchman Method (18.6MPa). The Adhesive Grinding technique (13.8MPa) had the least shear bond strength value but well above the accepted SBS value [Table/Fig-4].

All the recycling methods showed evidence of leaving behind residual debris on the bracket base as shown by UV/Vis spectrophotometer and light microscope at 4X magnification [Table/Fig-5,6a-f]. Although negative correlation existed between residual debris and shear bond strength value for all the methods, none of them were statistically significant, suggesting that the amount of residual debris following recycling has very little effect on the shear bond strength of recycled brackets but it may be affected by other factors like the bracket base design, the type of adhesive material used.

DISCUSSION

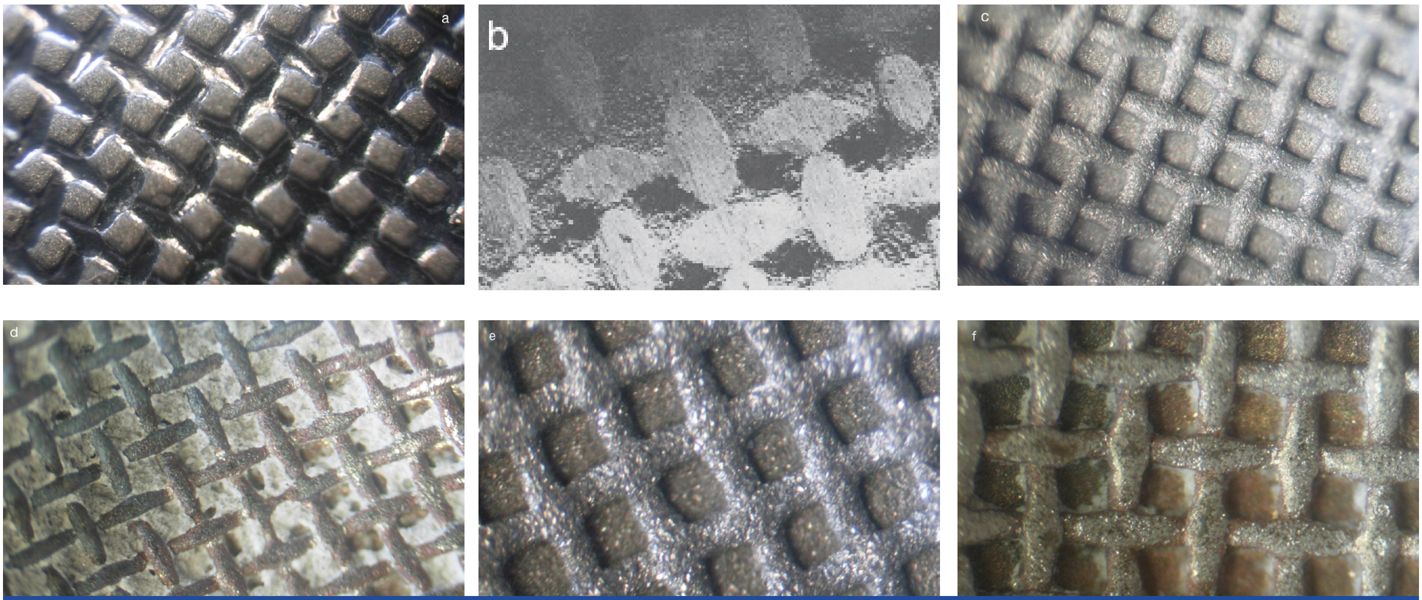
Direct bonding of orthodontic brackets since its inception into orthodontics has made tremendous advances and continuous efforts are on to find better bonding materials as bracket dislodgement continues to be a problem for orthodontists, leading to unwarranted delay and an escalated cost in treatment. Recycling has been the subject of debate within the profession following the regulations concerning the use and reuse of medical devices Jones and Andrew had reported, recycling the orthodontic brackets has a major advantage in ecological conservation and reduction in cost apart it also has disadvantages such as reduction in bracket quality, major being reduction in bond strength to the range of 6-20% [8,9].

Brackets can be recycled by sending them to commercial recycling companies (Orthocycle co., Esmadent co.) but these are complex procedures and require time and impractical to perform by chair side and usage of a new bracket would seem more feasible rather than sending them to such recycling companies. Thereby, to overcome the delays associated with commercial recycling, in-house methods have been developed. Previous studies have shown that in-house or chair side recycling methods also produces comparable results and more importantly meets the clinical requirements [10-12].

Studies by Buchwald et al., have shown that adhesive is left behind on the bracket base in the form of residual debris after recycling [13]. Even if residual debris is found after recycling brackets, there have been no studies done to quantify the amount of residual debris

Adhesive Grinding		Sandblasting		Thermal Flaming		Buchman Method		Acid Bath Method	
Control Bracket	Test Bracket	Control Bracket	Test Bracket	New Bracket	Test Bracket	New Bracket	Test Bracket	New Bracket	Test Bracket
2.220	1.699	2.123	1.872	1.664	1.332	2.025	1.753	1.724	1.454
2.223	1.979	2.170	1.831	1.662	1.311	2.021	1.732	1.725	1.446
2.226	1.247	2.116	1.869	1.680	1.369	2.018	1.726	1.749	1.447
2.221	1.867	2.128	1.871	1.678	1.361	2.021	1.712	1.781	1.449
2.221	2.059	2.161	1.813	1.698	1.323	2.019	1.771	1.736	1.443
2.223	2.111	2.153	1.846	1.688	1.366	2.015	1.732	1.771	1.446
2.222	1.676	2.124	1.820	1.695	1.310	2.018	1.711	1.728	1.446
2.224	1.477	2.127	1.828	1.679	1.368	2.022	1.732	1.762	1.450
2.223	2.033	2.153	1.872	1.685	1.322	2.022	1.741	1.732	1.444
2.222	1.669	2.143	1.859	1.695	1.329	2.019	1.715	1.709	1.453
2.224	2.056	2.134	1.865	1.691	1.355	2.017	1.719	1.755	1.456
2.225	1.254	2.125	1.828	1.667	1.328	2.024	1.734	1.738	1.456
2.226	1.998	2.135	1.833	1.693	1.343	2.017	1.704	1.741	1.449
2.225	1.620	2.145	1.847	1.683	1.377	2.012	1.735	1.744	1.454
2.224	1.716	2.151	1.855	1.676	1.355	2.021	1.755	1.751	1.446
2.226	1.953	2.133	1.875	1.694	1.365	2.025	1.765	1.761	1.448
2.227	2.088	2.126	1.859	1.682	1.349	2.022	1.721	1.741	1.456
2.225	1.866	2.172	1.873	1.694	1.363	2.018	1.713	1.711	1.450
2.227	1.404	2.123	1.834	1.687	1.354	2.023	1.746	1.763	1.443
2.229	1.788	2.121	1.881	1.690	1.351	2.019	1.763	1.721	1.448

[Table/Fig-5]: UV absorbance of control bracket and test bracket for 5 groups
p-value<0.001-Significant



[Table/Fig-6a-f]: (a) Base of New bracket (b) Base of Adhesive Grinding (c) Base of Sandblasting (d) Base of Thermal Flaming (e) Base of Buchman Method (f) Base of Acid Bath Method

left behind and little information exists regarding the effect of these remnants on the bond strength of recycled brackets.

This study, therefore, was taken up to assess whether the presence of residual debris after recycling affect the shear bond strength of the brackets. The in-house recycling methods employed in the study are Adhesive grinding method, Sandblasting method, Direct flaming method, Buchman method and Acid bath method. Except for Adhesive grinding the rest four methods involved exposing the bracket to various extreme conditions, which might influence the UV absorption levels. In order to ensure that the recycling procedures as such did not influence the UV absorption levels, 'CONTROL' brackets of Group III to VI, which were new brackets, was subjected to its specific recycling procedure but without the adhesive on the base. The UV absorption levels obtained from these brackets were used to act as control for its specific group in each of the different groups. The recycled 'TEST' brackets belonging to the Groups III to VI were then subjected to UV spectrophotometer. Any difference seen in the absorption levels after recycling was attributed to the presence of residual debris on the base of a recycled bracket. Shear load was applied with Universal Instron testing machine at a crosshead speed of 0.5mm/min.

In Adhesive grinding technique, grinding of the base leaves behind a smooth surface with much of the mesh being scraped off leading to low bond strength values. This co-related with the findings of Wright and Powers [12]. The UV/Vis spectrophotometer absorbance values indicate that the base of the bracket after the Adhesive grinding technique had a considerable amount of residue left on the bases of new and recycled brackets leading to the low values obtained in this study.

The Sandblasting method showed an increase in shear bond strength values and it can be attributed to micro roughness created by the alumina particles and therefore creates an increased bonding surface area, which is essential for retention. The present study results [Table/Fig-3] also co-related with the findings of Millet et al., Neumann et al., and Rajagopal et al., stated that the effect of sand blasting for an extended duration of time is of concern as this may lead to loss of valuable undercut area, to an extent that the bond strength may be compromised [14-18].

In direct flaming method, removal of the acrylic-bonding agent is the most critical part of the recycling process and requires long exposure to heat. Exposure to heat may lead to stress relieving or softening of cold worked metal along with decreasing corrosion resistance. At the same time, this may produce a layer of metal oxide, which needs to be removed by electro polishing. Previous studies by Bishara et al., have shown that electro polishing leads to a possible slot widening in the bracket and may render it more vulnerable to masticatory damage [19]. Huang Tsui-Hsien et al., stated that brackets recycled by the thermal method also render them more susceptible to tarnish and corrosion and this in turn can be responsible for its failure in the mouth [20]. The mean recycled shear bond strength value is less when compared to other methods but was well above the recommended value for clinical usage given by Reynolds [4].

The SBS strength results of Buchman method co-related with the findings of Vlock et al., where the mean recycled shear bond strength stood at 18.60 ± 2.02MPa, which was marginally below than that showed by Sand blasting [21]. This may be due to the fact that in Buchman method the brackets were electro polished after the flaming process. However, flash electro polishing could be done which does not remove more than 5–10 μ of metal, which according to Wheeler and Ackerman does not significantly affect the bond strength [22].

Salahuddien D and Omana G suggested the acid bath method, where acid rapidly removes any tarnish caused by the flaming process, dissolves any adhesive residue and also has a disinfectant effect [23]. In this study, this method showed mean recycled shear bond strength of 19.13 ± 2.07, which was marginally higher than both direct flaming and Buchman method but lesser than sand blasting. Another finding was that the recycled bracket looked more or less like a new bracket and hence would be aesthetically pleasing for patients.

The mean shear bond strength values of all the groups including that of new stainless steel brackets were estimated. It was found that new stainless steel brackets showed the maximum shear bond strength and Sand blasting technique had the highest recycled shear bond strength and least by Adhesive grinding method. The recycling procedures had shown significant differences in UV absorption before and after the recycling procedure, Group II was significantly different from all the other groups however there was no significant difference between the remaining groups. UV absorption difference was maximum in adhesive grinding method and minimum in Buchman method.

LIMITATIONS AND FUTURE SCOPE OF THE STUDY

This study has been carried out simulating the oral conditions as much as possible, but still their remains a gap to be bridged.

Therefore further researches in terms of in vivo studies are desired to depict more realistic clinical situations.

The Acid Bath method is simple, quick and inexpensive. But further studies should be done to know the effect of acid on the mesh pattern, slot dimensions and other physical properties.

CONCLUSION

Among the 5 in-house methods of recycling methods, Sandblasting method proved to have higher SBS values, but sandblasting done for an extended period of time may lead to loss of valuable undercut area resulting in reduced bond strength. Adhesive Grinding method, which appears the easiest of the five procedures, showed shear bond strength much below the values shown by other methods.

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