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Original Research

Evaluation of tensile bond strength of new and recycled orthodontic bracket

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ABSTRACT:
Aim- This study aims to compare the tensile bond strength between new and recycled orthodontic brackets. **Materials and methods-** A total of 50 extracted maxillary and mandibular incisors were collected were used in this study. These teeth, extracted for orthodontic purposes, were stored in saline for no more than six months. The materials included orthodontic brackets (0.022"x0.028"), a light-curing unit, a sandblasting machine with 50 µm aluminum oxide particles, a universal testing machine (UTM), adhesive, and primer. Out of the 50 samples, 25 were assigned as the experimental group (Group B), where the bonded brackets were debonded using a debonding plier and sandblasted with 50 µm aluminum oxide for 20-30 seconds to remove visible composite. The control group (Group A) consisted of 25 new brackets bonded directly to the tooth surface. Data analysis was done using SSPS software. **Results-** The comparison of tensile bond strength between the control group (Group A) and the experimental group (Group B) shows that Group A, consisting of 25 samples with new brackets, had a mean tensile bond strength of 3.93 MPa and a standard deviation of 3.56. Group B, which included 25 samples with recycled and sandblasted brackets, recorded a mean tensile bond strength of 3.12 MPa with a standard deviation of 1.87. The p-value for the comparison was 0.06, indicating no statistically significant difference between the two groups. **Conclusion-** The tensile bond strength of new orthodontic brackets is comparable to that of recycled orthodontic sandblasted brackets, and both are clinically acceptable.
Keywords- tensile, orthodontic, bracket

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INTRODUCTION

Patients pursuing orthodontic treatment, including a growing number of adults, often prioritize superior aesthetics alongside an improved smile. However, the use of fixed orthodontic appliances has historically elicited specific anxieties among patients. Striking a balance between the patient's aesthetic expectations and the orthodontist's technical requirements has been a persistent challenge. Orthodontic brackets play a crucial role in ensuring effective treatment outcomes by providing a reliable interface between the appliance and the tooth surface. Efforts to meet this balance have included modifying the appearance or size of stainless steel brackets, positioning the appliance on the lingual sides of the teeth, and exploring alternative materials for bracket construction. While smaller stainless steel brackets are increasingly popular and meet orthodontists' technical standards, they offer limited aesthetic advantages over similar-sized appliances.[1,2]

Over time, the need to recycle orthodontic brackets has gained attention due to economic and environmental considerations. The process of recycling brackets involves cleaning, reconditioning, and rebonding previously used brackets. However, this raises questions about their tensile bond strength compared to new brackets, as this factor is critical for maintaining treatment efficiency and minimizing appliance failure. [3,4,5]

The recycling of metallic direct-bond orthodontic brackets has gained significant interest due to its cost-effectiveness compared to purchasing new appliances.

Recycling involves removing the bonding agent from the brackets, often followed by electropolishing to enhance surface smoothness. Companies like Esmadent (Company E), Ortho-Cycle (Company O-C), offer these services, though they provide limited information on their specific processes. Company E heats brackets to 454°C for 45 minutes, a range associated with carbide precipitation, potentially weakening the alloy and reducing corrosion resistance. Company O-C employs solvent stripping at temperatures below 100°C, followed by heat sterilization at 250°C, while Company O-B requests adhesive details but provides no specifics on its method. Heat exposure plays a critical role in recycling, as temperatures between 400°C and 900°C can lead to structural weakening and reduced corrosion resistance of austenitic stainless steel, commonly used in brackets.[6,7]

Electropolishing, used to improve surface smoothness and reduce tarnish or corrosion, is considered a minimal-impact step as it removes negligible amounts of metal. Careful handling during bracket removal is essential to avoid distortion that might render brackets unsuitable for recycling. While electropolishing does not significantly alter slot configurations, improper heat treatment could anneal the metal, affecting its hardness and tensile strength irreversibly. Hence this study aims to compare the tensile bond strength between new and recycled orthodontic brackets.

MATERIALS AND METHODS

A total of 50 extracted maxillary and mandibular incisors were collected were used in this study. These teeth, extracted for orthodontic purposes, were stored in saline for no more than six months. The materials included orthodontic brackets (0.022”x0.028”), a light-curing unit, a sandblasting machine with 50 µm aluminum oxide particles, a universal testing machine (UTM), adhesive, and primer.

For bonding, the teeth were cleaned ultrasonically, polished with pumice paste, rinsed, and dried. The buccal surface was etched with 37% phosphoric acid for 30 seconds, rinsed thoroughly, and air-dried. A thin coat of primer was applied to the tooth surface and bracket base, followed by adhesive application. The brackets were firmly pressed onto the tooth surface, and excess adhesive was removed before curing for 30 seconds using a light-curing unit with an intensity of 450-480 nm.

Out of the 50 samples, 25 were assigned as the experimental group (Group B), where the bonded brackets were debonded using a debonding plier and sandblasted with 50 µm aluminum oxide for 20-30 seconds to remove visible composite. The control group (Group A) consisted of 25 new brackets bonded directly to the tooth surface. Statistical Data analysis was done using SSPS software.

RESULTS

Table I: Comparison of Tensile Bond Strength between Control and Experimental Groups

	GP	N	Mean	Std. Deviation	P value
Tensile bond strength (Mpa)	Group A	25	3.93	3.56	0.06
	Group B	25	3.12	1.87	

The comparison of tensile bond strength between the control group (Group A) and the experimental group (Group B) shows that Group A, consisting of 25 samples with new brackets, had a mean tensile bond strength of 3.93 MPa and a standard deviation of 3.56. Group B, which included 25 samples with recycled and sandblasted brackets, recorded a mean tensile bond strength of 3.12 MPa with a standard deviation of 1.87. The p-value for the comparison was 0.06, indicating no statistically significant difference between the two groups.

DISCUSSION

The tensile bond strength of orthodontic brackets is a critical factor influencing the success of orthodontic treatment. Maintaining a strong bond between the bracket and the tooth is essential to ensure effective force transfer and prevent premature debonding, which can lead to treatment delays and compromised results. While the use of recycled materials in various industries is gaining momentum for environmental reasons, their application in dentistry, particularly in orthodontics, requires thorough investigation to ensure biocompatibility and comparable performance to traditional materials. This includes evaluating the tensile bond strength of brackets manufactured from recycled materials compared to those made from new materials, a key indicator of their clinical suitability.[8,9]

In our study the comparison of tensile bond strength between the control group (Group A) and the experimental group (Group B) shows that Group A, consisting of 25 samples with new brackets, had a mean tensile bond strength of 3.93 MPa and a standard deviation of 3.56. Group B, which included 25 samples with recycled and sandblasted brackets, recorded a mean tensile bond strength of 3.12 MPa with a standard deviation of 1.87. The p-value for the comparison was 0.06, indicating no statistically significant difference between the two groups.

In a study by Buchman et al.,[10] the recycling of metallic direct-bond orthodontic brackets was identified as an area of growing interest within the profession. The research evaluated the impact of four recycling methods—Esmadent, Ortho-Cycle, Ortho-Bonding, and the author’s flame method—on bracket base torque, slot width, and mechanical properties. The findings showed no statistically significant differences among the four methods in terms of changes to base torque angle and slot width. In the control group, a small yet statistically significant number of brackets exhibited slot width changes of no more than 0.0015 inches (0.038 mm), with fewer than 20% of brackets showing any measurable change.

The recycling processes used by the author and Ortho-Bonding caused a loss of ferromagnetism, indicating that the metal had undergone annealing. Thermal treatment effects were further assessed through hardness testing, tensile strength measurements, and microstructural evaluation. While the Ortho-Cycle method preserved the mechanical properties of the bracket metal, the Esmadent method introduced subtle changes, and both the author's method and Ortho-Bonding caused carbide separation. Although dimensional changes were clinically insignificant, alterations in the metallurgical microstructure raised concerns about increased susceptibility to intergranular corrosion.

In another study Khanal PP et al.[11] evaluated and compared the effects of different recycling methods on the shear bond strength of stainless steel orthodontic brackets. The study involved 120 human premolars extracted for orthodontic purposes, which were randomly divided into four groups. Standard MBT (0.022″) brackets were bonded to the buccal surfaces of all samples using light-cured adhesive primers and an LED curing unit for 10 seconds. Group I served as the control, while the brackets in Group II, Group III, and Group IV were recycled using flaming, flaming with sandblasting, and flaming with ultrasonic cleaning, respectively. The recycled brackets were rebonded, and final debonding of all brackets was performed using a universal testing machine at a crosshead speed of 0.5 mm/min to determine shear bond strength. The study concluded that new brackets had significantly higher shear bond strength than recycled ones. Among the recycling methods, flaming with sandblasting yielded adequate shear bond strength, flaming with ultrasonic cleaning produced borderline values for clinical use, and flaming alone resulted in significantly lower bond strength.[11]

CONCLUSION

The tensile bond strength of new orthodontic brackets is comparable to that of recycled orthodontic sandblasted brackets, and both are clinically acceptable.

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