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Original Article

Dentistry Section

Comparison of Shear Bond Strength and Adhesive Remnant Score of Orthodontic Brackets Bonded with Three Different Orthodontic Adhesives: An In-vitro Study

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ABSTRACT

Introduction: Adequate bond strength between orthodontic brackets and enamel is necessary to withstand masticatory forces. Priming involves applying a primer before using the adhesive as a separate step. To reduce bonding time, manufacturers have introduced self-priming adhesives.

Aim: To evaluate the Shear Bond Strength (SBS) and Adhesive Remnant Index (ARI) scores of a Bis-GMA based self-priming adhesive (Orthofix SPA, Anabond) and compare it with a 2-Hydroxyethyl Methacrylate (HEMA) based self-priming adhesive (Aqualine LC, Tomy ortho) and a Bis-GMA containing primer-based orthodontic adhesive (Transbond XT, 3M).

Materials and Methods: The present In-vitro study was conducted at the White Lab., Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India, from December 2020 to January 2021. A total 54 freshly extracted premolar teeth were collected and divided into three groups (Group A - Orthofix SPA, Group B - Transbond XT, and Group C - Aqualine LC) based on the adhesive used. A 0.022 metal orthodontic brackets were bonded, and SBS and ARI scores of the samples were assessed. The Shapiro-Wilk test for normality was conducted. One-way Analysis of Variance (ANOVA) was used to compare the mean and standard deviation of SBS values and ARI scores among the three groups, and a post-hoc Tukey test was performed for inter group comparisons.

Results: Significant inter group differences were observed (p=0.004). Group A had lower SBS than Groups B and C. Significant inter group differences (p-value of 0.003) in ARI scores were noted, with Group A having the lowest scores.

Conclusion: The Bis-GMA self-priming adhesive (Orthofix SPA) exhibited lower SBS and ARI scores compared to commercially available HEMA-based self-priming adhesive systems and primer-based Bis-GMA adhesive systems.

Keywords: Bonding, Composite, Primerless, Self priming adhesive

INTRODUCTION

Bonding of orthodontic attachments to tooth enamel is a crucial step in orthodontic treatment, facilitated by using adhesives after etching the enamel surfaces [1]. Priming the etched enamel surface moisturises and protects it from demineralisation caused by bacterial actions [2]. Although priming is beneficial, omitting it can reduce the time required for placing attachments [3]. SBS refers to the maximum force an adhesive joint can withstand without fracturing [4]. Clinical bonding has been found to be successful with an SBS of 6-8 MPa [5,6]. Bracket bond failures can occur immediately after placement when subjected to occlusal loading [7]. Adhesive contraction during bonding or routine oral functions like mastication can lead to bond failures [8]. Numerous studies on the bond failure rates of various adhesive systems have already been published [9-12].

Orthofix SPA is a recently introduced single-component light-cure paste system designed for bonding both metal and ceramic orthodontic brackets to enamel. It is a Bis-GMA based self-priming adhesive, and since it does not require a separate priming step, it reduces chair-side time for operators [13]. There are currently no studies comparing this self-priming adhesive with other adhesives. Therefore, the purpose of present study was to assess the SBS and ARI scores of a Bis-GMA based self-priming adhesive (Orthofix SPA, Anabond) and compare it with a commercially available HEMA-based self-priming adhesive (Aqualine LC, Tomy ortho) and a Bis-GMA-based primer orthodontic adhesive (Transbond XT, 3M).

MATERIALS AND METHODS

The present In-vitro study was conducted at the White Lab, Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India, from December 2020 to January 2021. The study was approved by the scientific review board of the institution (IRB number: SRB/SDC/ORTHO-2007/22/014).

Study Procedure

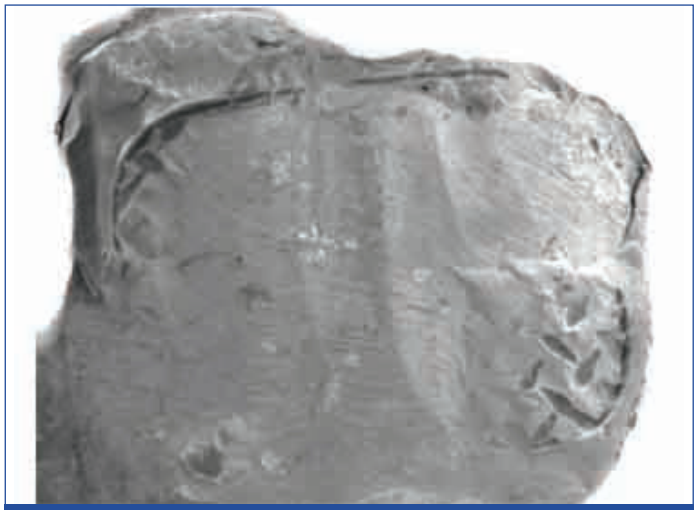
Total 54 freshly extracted healthy premolar teeth, without caries, restorations, or developmental anomalies, were collected and used for the study. The sample size for the current investigation was determined based on a prior study [14]. With a significance level of 0.05 and a power of 95%, a final sample of 54 teeth was obtained.

The extracted premolars were soaked in hydrogen peroxide for 24 hours. After 24 hours, the samples were cleaned with distilled water and stored in saline. Eighteen samples were assigned to each group: Group A - Orthofix SPA, Group B - Transbond XT, and Group C - Aqualine LC light-cure adhesive systems. Metal premolar brackets (0.022*0.028 inches, 3M Unitek Gemini) were bonded to the facial surfaces after pumice polishing and etching with 37% phosphoric acid thixotropic etching gel (Axotech), following the manufacturer's recommendations. Subsequently, all samples were individually mounted in acrylic resin blocks, with only the coronal part visible [Table/Fig-1]. SBS was assessed using an Instron Universal testing equipment (Instron E3000 UTM, Norwood, MA, USA). The equipment was equipped with a flattened steel rod for applying occlusal-gingival pressure to the bonded brackets, resulting in a shear force at the bracket-tooth interface. The measurements were recorded in Megapascals (MPa) [15].

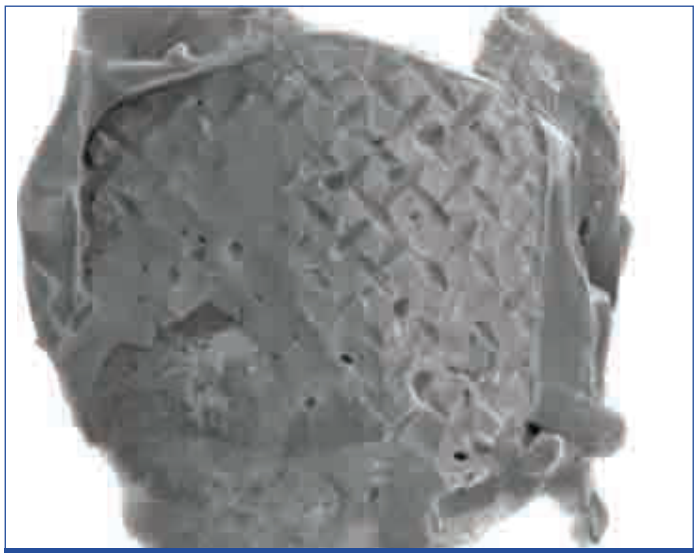
After debonding the mounted teeth with brackets, the coronal portion was sectioned. The ARI scores were evaluated according

to Artün and Bergland's method, which involved quantifying the amount of adhesive residue left on each tooth enamel surface using a Scanning Electron Microscope (JSM-IT800 NANO SEM) [Table/Fig-2-4] [16].

[Table/Fig-1]: Freshly extracted mounted teeth bonded with brackets.



[Table/Fig-2]: Scanning electron microscope image of enamel surface after debonding of Group A.



[Table/Fig-3]: Scanning electron microscope image of enamel surface after debonding of Group B.

STATISTICAL ANALYSIS

Based on the data analysis, a chart was constructed, and statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) (Version 26 Inc., Chicago, IL, USA). The Shapiro-Wilk test was conducted to assess normality. The mean and Standard Deviation (SD) of the SBS values and ARI scores of the three groups were compared using one-way ANOVA. The post-hoc Tukey test was performed to compare between the groups. p-values below 0.05 were considered significant.

RESULTS

The Shapiro-Wilk test and P-P plot, as well as numerical and graphical normality tests, indicated that the dependent variables were normally distributed.

SBS: The mean and SD of SBS in Group A, Group B, and Group C were 0.81±0.5 MPa, 8.55±4.1 MPa, and 9.08±6.5 MPa, respectively. There was a statistically significant difference observed between the groups (p=0.004) [Table/Fig-3,5]. Significant differences were noted between groups in the post-hoc comparisons, except between Group B and Group C [Table/Fig-6]. Group A exhibited the lowest SBS.

[Table/Fig-4]: Scanning electron microscope image of enamel surface after debonding of Group C.

Varaibles	Groups	Mean	SD	p-value
ARI	Group A	1.29	0.95	0.003
	Group B	2.43	0.78	
	Group C	2.86	0.37	
Compressive stress at maximum force (Mpa)	Group A	0.81	0.50	0.004
	Group B	8.55	4.19	
	Group C	9.08	6.54	

[Table/Fig-5]: Comparison of ARI scores and Shear Bond strength of all three groups.

Varaibles	Groups		Mean difference	p-value
ARI	Group A	Group B	-1.14	0.02
		Group C	-1.57	0.003
	Group B	Group A	1.14	0.02
		Group C	-0.42	0.54
	Group C	Group A	1.57	0.003
		Group B	0.42	0.54
Compressive stress at maximum force (Mpa)	Group A	Group B	-7.74	0.01
		Group C	-8.26	0.008
	Group B	Group A	7.74	0.01
		Group C	-0.52	0.97
	Group C	Group A	8.26	0.008
		Group B	0.52	0.97

[Table/Fig-6]: Post-hoc comparisons between the groups.

ARI scores: The mean ARI scores for all the groups are presented in [Table/Fig-5]. The inter group difference was statistically significant (p-value=0.003). In the post-hoc comparisons, significant differences were noted between groups, except between Group B and Group C [Table/Fig-6].

S. No.	Author's name and year	Place of study	Sample size	Materials compared	Parameters assessed	Conclusion
1	Chitra P 2016 [19]	India	120 premolar extracted teeth	Group I-Light cured primerless orthodontic composite (Heliosit). Group II-Light cured composite resin (Transbond XT) Group III-Light Cured GIC (GC Fuji Ortho LC). Group-Self-Cured Composite Resin (Rely-A-Bond).	Shear Bond Strength (SBS) and Adhesive Remnant Index (ARI)	The optimum properties of Heliosit® light cured primerless orthodontic composite include an adequate bond strength and a low risk of enamel damage during debonding.
2	Ramsundar K et al., 2022 [20]	India	28 premolar extracted teeth	Group I-Light cure orthodontic composite with primer (Transbond XT). Group II-Light cure orthodontic composite with primer (Ormco Enlight). Group III-Light cure orthodontic composite without primer (Transbond XT). Group IV-Light cure orthodontic composite without primer (Ormco Enlight).	SBS and ARI	The study showed no significant differences between the four groups.
3	Vaheed NA et al., 2018 [23]	India	60 premolar extracted teeth	Group I: Conventional Acid Etching (Transbond XT). Group II: Seventh-generation adhesive materials (Xeno V). Group III: Flowable composite (Filtek Z350 XT).	SBS and ARI	In comparison to flowable composites and conventional acid etching, the seventh generation showed greater SBS.
4	Present study	India	54 premolar extracted teeth	Group A: Orthofix SPA, Group B: Transbond XT Group C: Aqualine LC light cure adhesive.	SBS and ARI	The Bis-GMA based self-priming adhesive (Orthofix SPA) had lower SBS when compared with HEMA based self-priming (Aqualine LC) and Bis-GMA containing primer-based (Transbond XT).

[Table/Fig-7]: Characteristic table of studies evaluating Shear Bond Strength (SBS) and Adhesive Remnant Scores (ARI) [19,20,23].

DISCUSSION

Bond failures in orthodontic practice increase treatment duration and costs, leading to the introduction of various adhesive systems. SBS and ARI scores are measured outcomes in the present study. SBS refers to the maximum force an adhesive joint can withstand before fracturing. Sufficient SBS is necessary to prevent undesirable bracket failures, which can affect overall treatment outcomes [4]. Bracket bond failures are directly related to the SBS of the adhesive used, and other factors such as bonding procedures, tooth surface and morphology, occlusal interferences, patient dietary habits, masticatory load, and treatment duration also influence bond failures [17,18]. Frequent bracket failures result in increased costs and treatment duration.

The current study aimed to assess the SBS and ARI scores of a Bis-GMA based self-priming adhesive (Orthofix SPA) and compare them with commercially available HEMA-based self-priming and Bis-GMA-based primer adhesive systems (Aqualine LC, Transbond XT). It was observed that the SBS of the Bis-GMA based self-priming adhesive was significantly lower than that of the Bis-GMA based primer adhesive and the HEMA-based self-priming adhesive. The bond strength of the novel primerless adhesive (Orthofix SPA) was lower than the recommended SBS (6-8 MPa) for successful clinical bonding [7]. ARI scores were significantly lower for the Bis-GMA based self-priming adhesive compared to the other adhesives.

In the current study, a comparison of the SBS was conducted between the Bis-GMA based self-priming adhesive and both a primer-based adhesive and a HEMA-based self-priming adhesive system. The results showed that the HEMA-based self-priming adhesive (Aqualine LC) exhibited the highest SBS. The lower SBS of the Bis-GMA based self-priming adhesive could be attributed to compositional differences and flow properties. Previous In-vitro studies have investigated the SBS of primerless adhesives and compared them with primer-based adhesives, consistently reporting lower SBS for primerless adhesives [19,20]. The findings of the current study align with these previous studies, with the only difference being the brands of adhesives used. In-vivo studies have also been conducted in the past, comparing clinical bond failures while using primerless adhesives for orthodontic bonding [10,21]. In a clinical study by Rai AK, a higher bond failure rate was reported when Transbond XT was used without a primer compared to using the primer along with the Bis-GMA based primer adhesive (Transbond XT) [21].

Samantha C et al., attempted to compare the clinical bond failures between two conventional primer-based adhesives (Orthofix, Transbond XT), but no literature on self-priming adhesives from the same company has been reported [22]. Vaheed NA et al., reported that lower ARI scores were associated with a higher chance of bond failures [23]. In the current study, it was observed that the Bis-GMA based self-priming adhesive exhibited the least ARI scores, indicating a weak bonding with the enamel surface [Table/Fig-7] [19,20,23]. Chang WG et al., and Bishara SE et al., reported that low ARI scores were beneficial in terms of reducing iatrogenic injury to the tooth during the debonding and polishing procedure [24,25]. According to an In-vitro investigation by Ramsundar K et al., there was no significant difference in bracket failures between primer-based and no primer-based adhesives [20].

In the current study, no significant difference in SBS was observed between the Bis-GMA containing primer-based adhesive (Transbond XT) and the HEMA-containing self-priming adhesive (Aqualine LC), and both materials exhibited good strength, indicating high clinical success. Various other studies have also reported good bracket survival when using the Bis-GMA containing primer-based adhesive (Transbond XT) [9,26,27]. The present study observed the highest SBS with the HEMA-based self-priming adhesive (Aqualine LC), and comparable ARI scores were noted for both the HEMA-based self-priming adhesive (Aqualine LC) and the Bis-GMA containing primer-based adhesive (Transbond XT). These two adhesives can be recommended for clinical use.

Limitation(s)

The major limitation of present study is the In-vitro assessment. Further clinical studies should be conducted to evaluate the bracket failure rate of the adhesives under clinical conditions.

CONCLUSION(S)

The Bis-GMA based self-priming adhesive (Orthofix SPA) exhibited lower SBS compared to the HEMA-based self-priming adhesive (Aqualine LC) and the Bis-GMA containing primer-based adhesive (Transbond XT). Additionally, the Bis-GMA based self-priming adhesive had very low ARI scores. Among the adhesives studied, the HEMA-based self-priming adhesive (Aqualine LC) showed the highest SBS. The ARI scores of the HEMA-based self-priming adhesive (Aqualine LC) and the Bis-GMA containing primer-based adhesive (Transbond XT) did not differ significantly.

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