ORIGINAL ARTICLE

Effect of thermocycling on shear bond strength of a conventional etch and rinse adhesive system

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Abstract

Aim: The objective of this study was to determine the effect of thermocycling on shear bond strengths (SBSs) of a light cured compositeafterdifferent thermal cycles.

Materials and methods:80 Bovine incisors were randomly divided into 4 groups of 20 teeth. **Each** teeth were etched with 37% phosphoric acid and brackets were bonded using a light cured composite (Resilience). Thermocycling was done between 5° C and 55° C for 500, 3000 and 6000 cycles in group 2,3 and 4 respectively. Teeth in group1 (control group) were not being thermocycled. The SBS values were measured by means of Dartec testing machine.

Results: The results showed significantly higher SBS values for the control group compared to test groups (2-3 and 4). No significant different was observed between test groups.

Conclusion: Thermal changes during thermocycling significantly reduce the mean SBS of conventional etch and rinse adhesive system (Resilience), but SBS in 500, 300 and 6000 cycles had no significant difference. **Clinical significance:** Alteration in values of shear bond strengths under thermocycling would be representative of expected behavior of orthodontic brackets in clinical situations.

Keywords: shear bond strength, thermocycling, bracket.

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Introduction

Direct bonding of brackets is the most common technique which has been used by about 90% of orthodontists in U.S [1]. Different types of adhesives have been used for bonding purposes in orthodontics, but light cured adhesives are the most popular ones for majority of orthodontists [1]. Achieving a low bond failure rate is a major goal in orthodontic practice and the issue of bonding has been widely studied to obtain higher bond strength. However, lack of clinical relevance of laboratory studies on bonding limits extrapolation of results of these studies to clinical situations [2]. One of the reasons for this is difference in environment between in vitro and in vivo situations. Changing temperature in oral cavity along with variations in stresses, humidity and amount and composition of plaque produce a complex environment that cannot be simulated in laboratory studies [2]. Orthodontic adhesives are affected by these variations and it is of great importance for us to determine whether these changes influence bond strength or not, therefore Bishara et al. [3] advised thermocyling for testing new adhesives. Effect of thermocyling on bond strength of self etching primers (SEPs) [3,4], one bottle versus SEPs [5], cianoacrylate adhesive [6], resin modified glass ionomers versus SEP [7], direct versus indirect bonding methods [8], glass ionomer cements and composite resins [9,10] has been studied. The aim of the current study was to evaluate the effect of thermocycling on SBS of conventional etch and rinse adhesive system (Resilience).

Materials and Methods

Eighty bovine incisors free of defects and cracks were collected. The teeth were cleaned and polished with pumice and prophylactic rubber cup and then stored in 0.1% thymol solution (weight/ volume) for infection control and stored in normal saline until the start of study. Teeth were conditioned with a 37% phosphoric acid gel for 30 seconds. Following acid application, buccal surface was rinsed completely for 20 seconds and dried with oil and moisture free air until the frosty white appearance was achieved. A thin adhesive resin layer (Resilience Ortho Technology, Tampa, Florida, USA) was applied on teeth surfaces by means of a brush. Metal brackets used in this study were stainless steel lower incisor brackets (Dentaurum Company, Ispringen, Germany) which were bonded using light cured composite resin (Resilience Ortho Technology, Tampa, Florida, USA). Following removal of excessive composite resin with aid of a dental explorer, curing was done by means of bluephase C8 light-emitting diode (LED) (Ivoclar vivadent, schaan, liechtenstein) for 20 seconds (10 seconds for each of occlusal and gingival directions). After bonding teeth were mounted in a block of self curing acrylic resin at the level of 1mm below the CEJ to stabilize the specimens in Dartec testing machine (Dartec, Zwick, Roell Group, UK). The teeth were positioned in the acrylic block in a manner that bracket bases were perpendicular to horizontal level. To prevent from thermal changes following setting process of acrylic resin the teeth were immersed in water for 10 minutes. After that all samples were stored in water at 37°c for 24 hours. Following water storage teeth were randomly divided into 4 groups as follows: group1 (control), group2, 3 and 4 (test groups).

The teeth in control group were not thermocycled, while the teeth in groups 2, 3 and 4 were thermocyled between 5°Cand 55°C for 500, 3000 and 6000 cycles respectively. The thermocyling protocol was done according to the international organization for standardization [11]. The SBS values was evaluated by Dartec testing machine with a cross head speed of one mm per minute until bracket failure, and the force needed to achieve bond failure was recorded in newtons. Shear bond strength was then calculated by dividing the values of force by bracket base area which was 10.62 mm^2 and reported in MPa.

Statistical analysis

Descriptive statistics including means and standard deviations (SD) of SBS values were calculated by means of SPSS software. ANOVA and Tukey tests were used for multiple comparisons. $p \leq 0.05$ considered significant for all statistical tests.

Results

The descriptive statistics including mean and standard deviation values are presented in table 1. The mean SBS value (MPa) for groups 1, 2, 3 and for was 21.61, 18.40, 17.95 and 16.87 respectively. According to ANOVA test (table1) there was significant difference between mean SBS values of study groups (P = 0.000). Multiple comparisons were done between groups by means of Tukey post hoc test (table2) which showed significantly higher SBS value for control group compared to test

groups ($p < 0.05$). The difference in the SBS of teeth in test groups was not statistically significant ($p > 0.05$).

Table 1 Descriptive statistics including mean shear bond strength (MPa) and standard deviations (SD) values for study groups (n = 20)

Groups	Thermocycling	Mean	SD	P value
1	0	21.61	3.65	
2	500	18.40	1.10	
3	3000	17.95	1.15	0.000
4	6000	16.87	1.58	
Total		18.71	2.75	

Discussion

Since introduction of acid etching by Buonocore in 1955 [12] and direct bonding of orthodontic attachment to enamel by Newman in 1965 [13] till now, direct bonding has been the most common method in orthodontics [1]. The conventional etch and rinse adhesive system using an enamel conditioner, a primer solution and an adhesive resin for bracket bonding is a routinely used technique in orthodontic clinics [14] , therefore in this study we used conventional etch and rinse adhesive system.

Regarding long duration of orthodontic treatments, evaluation of clinical durability of materials is of great importance. Orthodontic adhesives are exposed to thermal changes in the complex oral environment which might affect clinical efficacy of these materials. It has been shown that even temperature, humidity and velocity of breathed air can change resting mouth temperature [15].

Several techniques have been described for evaluation of biomaterial's strength and durability. One of the most common techniques to simulated aging is long term water storage; thermocyling is another widely used technique to produce artificial aging [16].

According to protocol of international organization for standardization thermocyling of 500 cycles between 5° C and 55° C is appropriate for aging simulation [11]. However, it seems too low to produce realistic results [15]. Previous studies have used different thermocyling regimens [7, 17, 18]. In this study we used three protocol of thermocycling consisted of 500, 3000 and 6000 cycles between 5° C and 55° C. Yuasa et al. in their study to evaluate effects of longterm storage and thermocycling on bond strength of two self primer adhesive system found no significant difference between mean SBS values after thermocycling for 6000 cycles (5° C/55° C) and two years water storage [16]. The result of their study confirmed the efficacy of thermocycling method to simulate aging. Therefore it can be concluded that thermocycling for 6000 cycles (5°/55°) probably can imitate situation similar to two years of water storage which is close to the duration of normal orthodontic treatment.

Bovine incisors were used in the present study since these teeth have characteristics similar to human teeth and provide us equal samples for experimental procedures [19, 20]. Brackets are bonded to bovine and human teeth in the same way [21], however bond strength to bovine teeth has been reported to be lower than that of human teeth [19, 20].

Results of this study revealed a significant higher mean SBS value for group 1 (control group) compared to thermocycled groups (2, 3 and 4), while no significant difference in SBS amounts was found between thermocycling of 500, 3000 and 6000 cycles. However Elekdag – Turk et al. found no significant difference among 0, 2000 and 5000 thermal cycles in SBS of brackets bonded to bovine teeth using conventional etch and rinse method [4], in contrast to findings of Elekdag – Turk et al. [4], Daub et al. found significant decrease in SBS value of metal brackets bonded with etch and rinse system after 500 thermal cycles [8], similarly Saito et al. showed significant decrease in SBS values after 2000 and 5000 thermal cycles [5]. It is difficult to compare results of different studies of bond strength measurements. Various methods used along with variations in tooth type, bonding technique, debonding method and different materials and adhesive systems make it complicated to compare various studies. Regarding difficulties in comparing the results of different studies, Fritz et al. recommended using a separate control group for each study [22].

The observed decrease in SBS values of test groups compare to control group can be explained by thermal changes and water exposure of samples during thermocycling. Since the coefficient of thermal expansion for brackets, adhesives and teeth are different; stresses are generated from repetitive contraction and expansion during thermocycling. Accumulation of these stresses by passing time reduces the adhesion of tooth and bracket and consequently leads to bond failure [6, 15, 23]. Another explanation for this observation is increase in water absorption by composite, composite solubility or combination of these two phenomena [18].

Conclusions

Thermal stresses during thermocycling significantly reduce the SBS of conventional etch and rinse adhesive system in comparison with no thermocycling, but different thermocycling of 500, 3000 and 6000 don't affect SBS of Resilience composite significantly.

Table 2 Multiple comparisons of SBS values between groups using Tukey test.

	Group1		**Group2**		**Group3**			**Group4**
	Mean difference	sig	Mean difference	Sig	Mean difference	Sig	Mean difference	Sig
Group1 (0 cycle)			3.21	*[a]	3.66	*	4.74	*
Group 2 (500cycles)					0.45	ns[b]	1.53	ns
Group 3 (3000cycles)							1.07	ns
Group 4 (6000cycles)								

Clinical significances

Evaluation of clinical behavior of orthodontic material such as brackets is an important issue which cannot be performed accurately through laboratory investigations. Since thermocycling of bonding interfaces is one of appropriate methods to simulate clinical situations, the results from this method can be extrapolated to clinical performance of orthodontic brackets.

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