Tikrit Journal for Dental Sciences 11(1) (2023) 131-139
ISSN:2073-1213
https://doi.org/10.25130/tjds.11.1.15 Tikrit Journal for Dental Sciences
https://tjds.tu.edu.iq

The Effect of Preheating of Orthodontic Resin on The Shear Bond Strength of Convensional Orthodontic Bracket to Enamel Surface

Omar Jasim Mohamed Taib [(1) *]
Omar Fawzi Chawshli [(2)]

[(1, 2)] Department of P.O.P, college of dentistry, Hawler Medical University, Iraq.

Article Info:
-Article History:
-Received: 9/8/2022
-Accepted: 4/9/2022
-Available Online:
Jun, 2023

Keywords:
Orthodontic Adhesive, Shear Bond Strength, Adhesive temperature, Pre-heating.

***Corresponding Author:**
Email:
omar.chawshli@hmu.edu.krd

Hawler Medical University/ faculty of dentistry- P.O.P department.

Abstract
Adequate bond strength between enamel and orthodontic bracket is crucial, several factors affect the bond strength including the adhesive temperature prior to bonding. The objective of the study was to investigate if there is any relationship between adhesive temperature prior to bonding and the Shear Bond Strength (SBS) of orthodontic bracket to the enamel surface. Method: In this in-vitro study, A total of 64 freshly extracted premolar teeth were used which were divided into four groups each one had different adhesive temperature prior to bonding (room temperature ,30°C, 50°C, and 70°C), and each group went through SBS test under Universal Instron machine and ARI score test using Stereomicroscope. Results: All pre-heated groups had a higher mean value than the room temperature group, while the mean value of SBS were highest in 70°C group but at 50°C there was a drop down in the SBS values which had a mean less than 30°C and 70°C groups. ARI scores showed not statistically significant different between the groups. Conclusion: Pre-heating orthodontic adhesive right before bonding to 70°C can significantly increase bracket SBS to enamel. While, preheating to 30°C could have a greater SBS than pre-heating to 50°C.

Introduction:

In fixed orthodontic treatment, the success of the treatment is influenced in part by the strength of the bond formed between the brackets and the teeth. An orthodontist today must establish treatment procedures that are as efficient, time-saving and error free as possible(1), so proper bonding between the enamel surface of the tooth and the bracket is essential. Failure of adhesion of the brackets to the surface of the teeth enamel increases the time and cost of the orthodontic treatment (1, 2) .

Bond strength is affected by many factors, such as the contamination, type of composite and adhesive viscosity, composite age and type of enamel etching procedure, storage conditions and bracket base shape or size, and type of test used to determine the bond strength. Temperature and humidity are also important factors (3). In clinical practice, clinicians use

adhesive materials from a refrigerator without allowing them to come to room temperature in order to extend their shelf life, even though most manufacturers recommend that adhesive materials be stored at room temperature. Intriguingly, a decrease in the adhesive's effectiveness can be caused by a drop in temperature. The physical and mechanical properties of the adhesive material may be adversely affected by changes in the adhesive material's waiting temperature by reduction in its polymerization (4). The polymerization of resins can't take place completely at room temperature (5) or when the light activation method isn't strong enough (6). Friedman described a polymerization method that involved heating the composite resin to 54–60°C before activating it with light in order to achieve a high monomer conversion rate (7). Polymerization depth and molecular mobility can both be improved by preheating (8-10). Despite the fact that preheating the composite resin significantly reduces the composite film thickness (11). Hence, this research was conducted to find the effect of changing the adhesive temperature on Shear Bond Strength (SBS) between the bracket and tooth's enamel after curing it. This research also tries to find the effect of pre-heating on the mode of failure through Adhesive Remanent Index (ARI).

Materials and methods:

64 human premolar teeth were collected and stored in normal saline solution, teeth pretreated with chemical agents such as alcohol, formalin or hydrogen peroxide were excluded, also teeth with hypoplastic enamel, cracks, fractures or caries were excluded too. Teeth were cleaned and soft tissue remnants and calculus were fully removed. All teeth were mounted horizontally in chemically activated acrylic resin until two-thirds of the root was embedded and the labial surface of the crown is fully exposed, Figure (1). Teeth polished with a rubber prophylactic cup and non-fluoridated pumice stone. After 10 seconds of streamed water rinsing, the teeth were dried. Teeth were divided and sorted randomly into four equal groups for bonding with Orthodontic adhesive: group (1): Room temperature, group (2): 30 Celsius degree of temperature, group (3): 50 Celsius degrees of temperature and group (4): 70 Celsius degrees of temperature.

Transbond XT adhesive from 3M was used in this experiment. A 35 percent phosphoric acid

Gel was used to etch the teeth for 30 seconds prior bonding and a syringe was used to rinse the teeth for 30 seconds followed by drying. Then, Transbond XT Primer (3M Unitek, Monrovia, CA, USA) is applied followed by air jet and three seconds of curing. Then the application of the orthodontic metal brackets (0.0220.030-inch, 3.4mm base width, Dentaurum Brackets discovery®, DENTAURUM GmbH & Co.KG, Ispringen, Germany) were used and adhered to the labial surface of mounted teeth after the application of the adhesive or the pre-heated adhesive for each group which is pre-heated for 10 minutes before application and photopolymerization using HeatSync composite warmer (HeatSync, Bioclear,Seattle, WA, USA). A surveyor is used to apply a weight of 300 gm to the bracket within 30 seconds, to achieve a uniform adhesive thickness between the bracket and the tooth Figure (2).

After that, the excess adhesive was removed and using a light-curing unit, curing was performed for 6 seconds per tooth and 3 seconds on each proximal face at 1200 mw/cm2 (Valo Ortho LED, Ultradent Products Inc., South Jordan, USA). For about 24 hours, the bonded specimens were stored in deionized water at temperature of 37°C.

Shear Bond Strength (SBS) Test

A universal testing machine (Universal Instron testing machine) was used to conduct the shear bond strength (SBS) test at a crosshead speed of 0.5 mm/min. as shown In Figure 3, the shearing wedge was positioned vertically at the bracket base and the SBS data was expressed in MPa.

Adhesive Remnant Index (ARI) scoring

After debonding, images were extracted from a computer-attached Stereomicroscope's camera and the brackets were examined under ×10 magnification, and the definition of ARI as follows: (5): the enamel surface is free from adhesive's paste; (4): less than 10 percent of the adhesive paste remaining, (3): more than10 percent but less than 90 percent of the adhesive paste remaining; (2): more than 90 percent of adhesive is remaining; (1): all the adhesive paste remained, with an impression of the bracket base on the surface(12) as shown in (Fig. 4) . On normally distributed data, one-way ANOVA and post hoc Tukey tests were done in the statistical analysis (SPSS 20.0; SPSS Inc, Chicago, IL, USA) of SBS (MPa) data (Shapiro–Wilks test). The chi-squared test was used to examine the distribution of ARI scores among the groups. P-value > 0.05 is the threshold for statistical significance.

Results:

The mean value of SBS were highest in 70°C group while all pre-heated groups had higher values than the room temperature group but at 50°C there was a drop down in the SBS values which had a mean less than both 30°C and 70°C groups, Table (1) shows the mean values of SBS for each group and fig (5) shows the plot graph for these values.

The One-Way ANOVA test showed a statistical significance different between mean values of the groups and Post Hoc Tukey's test showed a statistically significant difference (p-value<0.05) only between group-1 (room temperature) and group-4 (70°C) and no significant difference between other groups as been shown in both Table (2) and Table (3). The ARI scores were established with 10x magnification under the stereomicroscope and the ARI scores for each group is shown in Table (4). In (Table 5) Chi-square test shows that there was a non-significance relation between the groups and ARI scores.

Discussion:

Some researchers have claimed that SBS around 2.86 MPa is clinically acceptable, and the lowest bond strength for orthodontic brackets is 6–8 MPa (13-16). Between 6.3–17.91 MPa, the bond strength of the adhesive was found at the four groups in the current study. Despite the reverse (17, 18), there have been some researches indicating that the temperature of adhesive at which adhesives are applied to teeth can affect their adherent strength (19-21). Temperatures of 25°C were found to have the lowest bond strength values in this study. Low temperatures reduce adhesive viscosity (22, 23), making wetting the dental tissue more difficult because the adhesive's speed slows down(24). There was a difference in SBS mean values between groups that had the adhesive pre-heated at lower temperature (25 degrees Celsius) and higher temperatures (30, 50 and 70 degrees Celsius). This is blamed to be caused by the decrease in viscosity, the increase in degree of transformation, and the radical mobility, thus shear bond strength values have increased (25). In addition, there may be a decrease in the adhesive's shear bond strength as the temperature rises from about 30°C to about 50°C, which is in line with other studies (26, 27). This could be due to adhesives components, such as BIS-GMA, MDP, and HEMA, can be chemically deteriorated at higher temperatures due to their instability at these temperatures (28). the values of shear bond strength obtained at above 60°C will continue to increase more than the values of both (30°C and 50°C) (group-4) like previously reported studies (27, 29). This may be due to an increase of the effect of reduction in adhesive viscosity, rise in radical mobility, and degree of transformation than the temperature at 50°C, which may have overcome the previous deterioration of the adhesive (25). Different materials' bond strength is measured using parameters like shear and tensile strengths. However, the limitation of these methods is that they can only be applied to flat surfaces. As it will have a low C factor and low of shrinkage

stress at the bonding interface (28) . Different adhesive materials, in vitro testing methods and adhesive thickness have all been shown to influence bond strength of orthodontic adhesives (30).Applying more than 200 g of force during the bracket bonding procedure is recommended in order to ensure adequate adhesive adhesion and a thin composite resin layer (32), and according to the findings of Muguruma et al. (31). A 300-g force was applied to the surveyor using a 300-g weight while gluing the brackets to standardize the adhesive thickness in this study. The failure of one of the three interfaces on the surface of the tooth is what causes orthodontic brackets to fail (bracket-cement failure, within cement failure and tooth-cement failure). Adhesive failure leaves no residue on the tooth surface, whereas cohesive failure leaves adhesive material on the tooth surface and the base of the brackets which will be visible on both (33).The adhesive failure occurs in the adhesive cement itself and between the cement and the tooth's surface, while cohesive failure is caused by the failure between the bracket and the adhesive cement. There should be sufficient bonding strength to withstand all mechanical forces applied by dentists, parafunctional forces, and chewing forces while preserving enamel integrity during debonding (34). It is possible for the enamel to be damaged if adhesive remains on the enamel surface rather than the bracket base after debonding due to cohesive failure, increasing the procedure's duration (35). Cohesive failure is therefore unfavorable. Following this, the ARI scores from this study were evaluated, and no differences between the four groups in terms of ARI score results were discovered. It was found that adhesive residue remained on the enamel and the bracket surface in 66% of samples. After the test, none of the specimens had enamel failure. SBS and ARI scores were found to be directly related by Faria-Jnior et al. (36). The higher the SBS value, the higher the ARI score. Making things more difficult in terms of predicting failure types, in this study the ARI scores for the highest bonding strength values in some groups varied. Like a recent study by Serdar Akarsu which showed that ARI scores and bonding strength values may not have relation. The Chi-square test in this study showed a non-significant relation between SBS and ARI scores which rejects the null hypothesis that there is a correlation between the two (26).

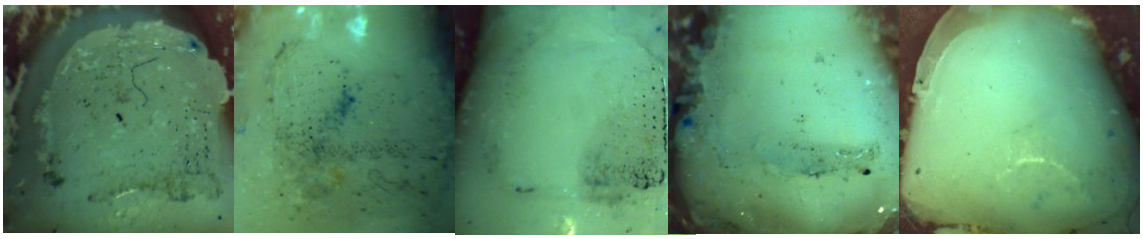
Conclusion:

- Pre-heating orthodontic adhesive right before bonding to 70°C can significantly increase bracket SBS to enamel. While pre-heating to 30°C and 50°C also increases the mean SBS more than the adhesive used at room temperature but pre-heating to 50°C had a lower SBS than pre-heating to 30°C.
- There was no statistically significant relation between SBS and ARI scores between the groups.

Fig. (1): Extracted Premolar mounted in acrylic.

Fig. (2): Surveyor with 300 gm weight applied on the bracket.

Fig.(3): Universal Instron testing machine.



1 2 3 4 5

Fig. (4): Example of samples in Adhesive Remnant Index scores

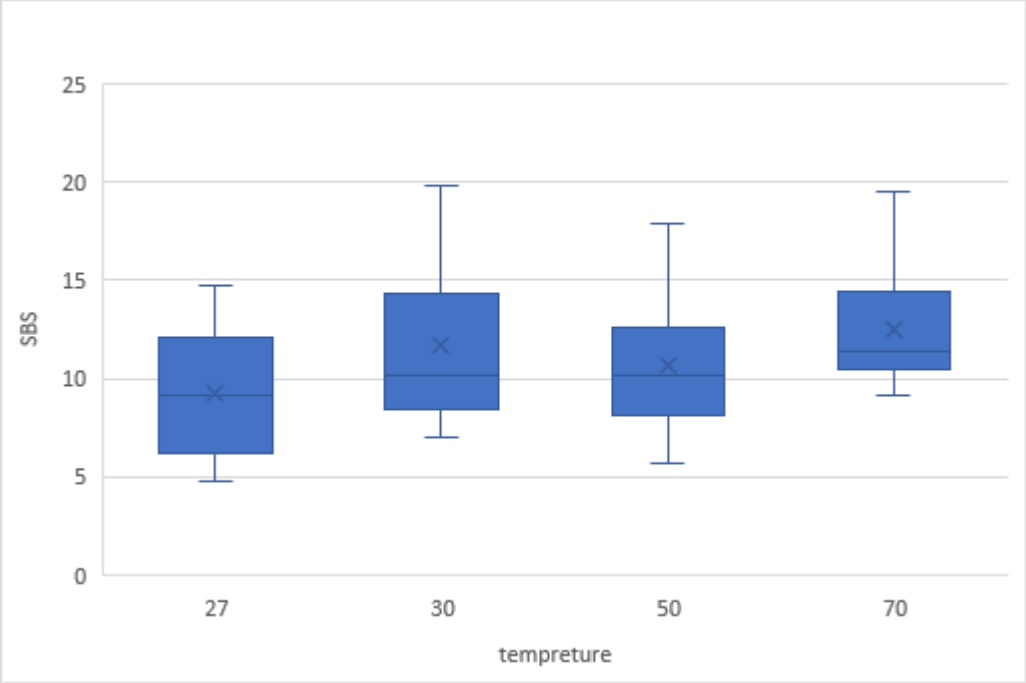


Fig. (5): plot graph shows the mean values for each study group

Table 1: Mean values of SBS for each group.

Means in MPa			
Temperature	Mean	N	Std. Deviation
Room temperature (25 °C)	9.1879	16	3.19869
30 °C	11.6274	16	3.79231
50 °C	10.6423	16	3.23634
70 °C	12.5395	16	3.16478
Total	10.9993	64	3.50814

Table 2: One-Way ANOVA test.

One-Way ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	132.032	3	44.011	2.921	.041
Within Groups	904.091	60	15.068		
Total	1036.123	63			

Table 3: Post Hoc Tukey's test.

Tukey HSD[a]			
		Subset for alpha = 0.05	
temperature	N	1	2
25°C	16	10.6213	
50°C	16	12.3025	12.3025
30°C	16	13.4412	13.4412
70°C	16		14.4956
Sig.		.180	.388

Table 4: ARI scores for each group.

ARI score * Temperature Crosstabulation

			Temperature				Total
			25°C	30°C	50°C	70°C	
ARI Score	(1) all adhesive	Count	0	0	3	1	4
	(2) >90	Count	1	2	1	2	6
	(3) <90 >10	Count	5	5	4	8	22
	(4) <10 not 0	Count	5	4	3	2	14
	(5) no remaining	Count	5	5	5	3	18
Total		Count	16	16	16	16	64
		Expected Count	16.0	16.0	16.0	16.0	64.0

Table 5: Chi-Square Test.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.398[a]	12	.581
Likelihood Ratio	11.012	12	.528
Linear-by-Linear Association	2.836	1	.092
N of Valid Cases	64		

References

1. Becker S. An In Vitro Comparison of Shear Bond Strength Between Two Orthodontic Light-Curable Adhesive Pastes: West Virginia University; 2021. *Graduate Theses, Dissertations, and Problem Reports. 8124*.

2. Powers JM, Kim HB, Turner DS, editors. Orthodontic adhesives and bond strengthtesting. Seminars in Orthodontics; 1997: Elsevier.

3. Nystrom G, Holtan J, Phelps R, Becker W, Anderson T. Temperature and humidity effects on bond strength of a dentinal adhesive. Operative dentistry. 1998;23:138-43.

4. Toledano M, Osorio R, Albaladejo A, Aguilera FS, Osorio E. Differential effect of in vitro degradation on resin–dentin bonds produced by self-etch versus total-etch adhesives. Journal of Biomedical Materials Research Part A: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials. 2006;77(1):128-35.

5. Papacchini F, Magni E, Radovic I, Mazzitelli C, Monticelli F, Goracci C, et al. Effect of intermediate agents and pre-heating of repairing resin on composite-repair bonds. Operative dentistry. 2007;32(4):363-71.

6. Acquaviva PA, Cerutti F, Adami G, Gagliani M, Ferrari M, Gherlone E, et al. Degree of conversion of three composite materials employed in the adhesive cementation of indirect restorations: a micro-Raman analysis. journal of dentistry. 2009;37(8):610-5.

7. Friedman J. Thermally assisted polymerization of composite resins. Contemp Esthetics Rest Practice. 2003;7:46.

8. Borges GA, Spohr AM, Oliveira WJd, Correr-Sobrinho L, Correr AB, Borges LH. Effect of refrigeration on bond strength of self-etching adhesive systems. Brazilian dental journal. 2006;17:186-90.

9. Daronch M, Rueggeberg F, De Goes M. Monomer conversion of pre-heated composite. Journal of dental research. 2005;84(7):663-7.

10. Mundim FM, Garcia LdFR, Cruvinel DR, Lima FA, Bachmann L, Pires-de FdCP. Color stability, opacity and degree of conversion of pre-heated composites. Journal of dentistry. 2011;39:e25-e9.

11. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dental materials. 2011;27(4):e51-e9.

12. Bishara SE, VonWald L, Laffoon JF, Warren JJ. Effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets.

American Journal of Orthodontics and Dentofacial Orthopedics. 2001;119(6):621-4.

13. Hammad SM, El Banna MS. Effects of cyclic loading on the shear bond strength of metal orthodontic brackets bonded to resin composite veneer surface using different conditioning protocols. Progress in orthodontics. 2013;14(1):1-6.

14. Saraç YŞ, Külünk T, Elekdağ-Türk S, Saraç D, Türk T. Effects of surface-conditioning methods on shear bond strength of brackets bonded to different all-ceramic materials. The European Journal of Orthodontics. 2011;33(6):667-72.

15. Littlewood S, Mitchell L, Greenwood D. A randomized controlled trial to investigate brackets bonded with a hydrophilic primer. Journal of Orthodontics. 2014.

16. Reynolds I. A review of direct orthodontic bonding. British journal of orthodontics. 1975;2(3):171-8.

17. Spohr AM, Borges GA, Sobrinho LC, Consani S, Sinhoreti MAC. Effect of refrigeration on tensile bond strength of three adhesive systems. Brazilian Dental Journal. 2001.

18. Sadr A, Ghasemi A, Shimada Y, Tagami J. Effects of storage time and temperature on the properties of two self-etching systems. Journal of dentistry. 2007;35(3):218-25.

19. Loguercio A, Salvalaggio D, Piva A, Klein-Júnior C, de Lr Accorinte M, Meier M, et al. Adhesive temperature: effects on adhesive properties and resin-dentin bond strength. Operative dentistry. 2011;36(3):293-303.

20. Reis A, Klein-Júnior CA, Accorinte MdLR, Grande RHM, dos Santos CB, Loguercio AD. Effects of adhesive temperature on the early and 6-month dentin bonding. journal of dentistry. 2009;37(10):791-8.

21. Vale M, Afonso F, Borges B, Freitas Jr A, Farias-Neto A, Almeida E, et al. Preheating impact on the degree of conversion and water sorption/solubility of selected single-bottle adhesive systems. Operative Dentistry. 2014;39(6):637-43.

22. Silikas N, Watts D. Rheology of urethane dimethacrylate and diluent formulations. Dental Materials. 1999;15(4):257-61.

23. Hagge M, Lindemuth J, Broome J, Fox M. Effect of refrigeration on shear bond strength of three dentin bonding systems. American journal of dentistry. 1999;12(3):131-3.

24. Hisamatsu N, Atsuta M, Matsumura H. Effect of silane primers and unfilled resin bonding agents on repair bond strength of a prosthodontic microfilled composite. Journal of oral rehabilitation. 2002;29(7):644-8.

25. Daronch M, Rueggeberg FA, De Goes M, Giudici R. Polymerization kinetics of pre-heated composite. Journal of Dental Research. 2006;85(1):38-43.

26. Akarsu S, Buyuk SK, Kucukekenci AS. Effects of adhesive systems at different temperatures on the shear bond strength of orthodontic brackets. Journal of Dental Research, Dental Clinics, Dental Prospects. 2019;13(2):103.

27. Borges BCD, Gurgel MV, Figueiroa AFA, Vilela ARRC, Pinheiro FHdSL, Braz R, et al. Improvement of the orthodontic bracket bond strength with pre-heated composite restoratives. Acta Odontologica Scandinavica. 2013;71(3-4):632-7.

28. Salz U, Zimmermann J, Zeuner F, Moszner N. Hydrolytic stability of self-etching adhesive systems. J Adhes Dent. 2005;7(2):107-16.

29. Karadağ G, Dereli Z, Kök H, Bağlar S. Effect of pre-heated resin composite application on the shear bond strength of orthodontic brackets after thermal aging. IJADS; 2018.

30. Arici S, Caniklioglu CM, Arici N, Ozer M, Oguz B. Adhesive thickness effects on the bond strength of a light-cured resin-modified glass ionomer cement. The Angle orthodontist. 2005;75(2):254-9.

31. Muguruma T, Yasuda Y, Iijima M, Kohda N, Mizoguchi I. Force and amount of resin composite paste used in direct and indirect bonding. The Angle Orthodontist. 2010;80(6):1089-94.

32. Mohammadi A, Pourkhameneh S, Sadrhaghighi A-H. The effect of different force magnitudes for placement of orthodontic brackets on shear bond strength, in three adhesive systems. Journal of clinical and experimental dentistry. 2018;10(6):e548.

33. Hegarty DJ, Macfarlane TV. In vivo bracket retention comparison of a resin-modified glass ionomer cement and a resin-based bracket adhesive system after a year. American journal of orthodontics and dentofacial orthopedics. 2002;121(5):496-501.

34. Katona TR. Stresses developed during clinical debonding of stainless steel orthodontic brackets. The Angle Orthodontist. 1997;67(1):39-46.

35. Trites B, Foley TF, Banting D. Bond strength comparison of 2 self-etching primers over a 3-month storage period. American journal of orthodontics and dentofacial orthopedics. 2004;126(6):709-16.

36. Faria-Júnior ÉM, Guiraldo RD, Berger SB, Correr AB, Correr-Sobrinho L, Contreras EFR, et al. In-vivo evaluation of the surface roughness and morphology of enamel after bracket removal and polishing by different techniques. American Journal of Orthodontics and Dentofacial Orthopedics. 2015;147(3):324-9.