Print ISSN: 2321-6379
Online ISSN: 2321-595X
DOI: 10.17354/ijss/2017/115

Original Article

Effect of Temperature Variation on Orthodontic Composite: An *In Vitro* Study

Tejashree Suresh Girme[1], Mayur Bidarkar[2], Jiwanasha Agrawal[3], Manish Agrawal[4], Sangmesh Fulari[4], Vishwal Kagi[5], Shraddha Shetti[6]

[1]Post-graduate Student, Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India, [2]Senior Resident, Department of Dentistry, Swami Ramanand Teerth Rural Medical College, Ambajogai, Beed, Maharashtra, India, [3]Head and Professor, Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India, [4]Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India, [5]Senior Lecturer, Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India, [6]Assistant Professor, Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India

Abstract

Introduction: One problem that clinicians face during treatment is bracket failure. This is usually the consequence of either a patient's accidentally applying inappropriate force to the bracket or a poor bonding technique. However, the effect of temperature variation on the tensile strength and hardness of composite resin had been also a considering factor during bonding.

Materials and Methods: A total of 45 freshly extracted human premolars were collected and stored in normal saline. Teeth were cleaned and separated into three groups. Each group contains 15 samples. Group I: Composite refrigerated at (−10°C); Group II: Composite at room temperature (25°C). Group III: Composite heated at temperature (45°C). Teeth were bonded accordingly and tested after 30 min with universal testing machine at cross head speed of 0.5 mm/min. the residual adhesives was been evaluated under microscope of ×10 magnification and scoring index had been made. The analysis of variance was used to determine whether significant differences existed between the various groups. Multiple range tests were used to identify which of the groups were different. The Chi-square test was used to determine significant differences in the adhesive remnant index scores between the different groups.

Results: Statistically significant results are obtained with respect to Group III composite heated at 45°C. Bond failure at enamel adhesive interface is seen and 90% of composite remained on the tooth.

Conclusion: Composite heated at high temperature had increased its bond strength. Amount of residue on enamel tooth interface with 90% remained on tooth.

Key words: Adhesive remaining index, Bonding, Composite, Cryopreservation, Debonding, Etchant

INTRODUCTION

Brackets are bonded to the surface of teeth with orthodontic adhesive. Bonding of orthodontic brackets to the tooth enamel has been an important issue since the introduction of direct bonding in orthodontics. Many new bonding agents have been developed such as composite resins, conventional glass ionomer cements, resin-modified glass-ionomer cements, and polyacid modified composites (compomers) with different polymerization mechanism such as chemically, light or dual curing. Composite resins are one of the most frequently used adhesives in orthodontic bonding. Although they provide sufficient bonding strength and are easy to handle, they adhere to the tooth enamel only by microretention, require dry field and amount of fluoride release have not been found to be sufficient for anticaries effect.

Composite resins and acid-etch techniques are presently an integral part of orthodontic treatment. To increase the shelf life of adhesives, some manufacturers recommend storing the material in the refrigerator before use. The temperature of the adhesive can vary significantly, depending on the time period between the removal of the

Access this article online

www.ijss-sn.com

Month of Submission : 01-2017
Month of Peer Review : 02-2017
Month of Acceptance : 02-2017
Month of Publishing : 03-2017

Corresponding Author: Dr. Tejashree Suresh Girme, Parvati Garde Nursing Home, Ramdas Path, Indapur, Pune, Maharashtra, India. Phone: +91-7744944844. E-mail: drtejugirme@gmail.com

bonding kit from the refrigerator (4-5°C) until it reaches room temperature (22-25°C). Bishara *et al*. the variation in the temperature of the composite, within the limits tested, does not seem to adversely affect the bonding strength of the bracket to the enamel.[1] Bishara *et al*. temperature variation affects the resin-reinforced glass-ionomer adhesive more than the composite adhesive in the first 30 min after bonding.[2] Awlia *et al*. the composite consumed heat during its manipulation and, in turn, initiated further cross-linking once the temperature was increased, raising the temperature increased the intrinsic strength of the composite.[3] Temperature variation might affect the viscosity of composites, but this appears to have little effect on the tag length of composites. The literature is scarce concerning the effects of such temperature variation of the composite during orthodontic bonding.

It has been also suggested that the temperature variation might affect the viscosity of the composites, but this appears to have little effects on the tag length of the composites. That is, temperature change has no effect on penetration of a composite.

The purpose of this study is to compare the bonding strength of two groups of teeth and to determine the effect of various temperature changes on the mechanical and adhesive properties of orthodontic composite.

Aim and Objectives

1. Aim: To determine effect of temperature on bond strength of composite adhesive.
2. Objectives:
   - To evaluate effective temperature range for composite adhesive.
   - To evaluate amount of residual adhesives after debonding.

MATERIALS AND METHODS

The *in vitro* study contains 45 extracted human premolars, all in good condition, were collected from Bharati Vidyapeeth Dental College, Sangli, stored in normal saline. The teeth were cleaned and then polished with a non-fluoride pumice. They were assigned randomly to three groups of 15 each. The preparations for bonding the brackets in the two groups were essentially similar: The teeth were air-dried, conditioned with 37% orthophosphoric acid for 15 s, and followed by immediate rinsing for 20 s. Teeth were air dried for 5 s. The total time duration for this study was 2 months approximately:

- Group I: For group of 15 teeth, the temperature of the bonding material was maintained at −10°C using cryopreservation (Figure 1).
- Group II: For group of 15 teeth, the temperature of the bonding material was maintained at room temperature 25°C.
- Group III: For group of 15 teeth, the temperature of the bonding material was maintained at 45°C using hot air oven (Figure 2).

To maintain a constant temperature, the bonding kit was kept in the refrigerator and oven accordingly for 15 min before bonding under normal office conditions; these would be the outer limits of temperature variation to which any bonding system would be subjected. Bonding system to the three groups of teeth was performed according to the standardized instructions (Figures 3-5).

The teeth were mounted in acrylic blocks and stored in normal saline for 24 h before they were debonded. The Instron Universal Testing Machine was used to determine the shear bond strengths at cross head speed of 0.5 mm/min (Figure 6).

Figure 1: Cryopreservation

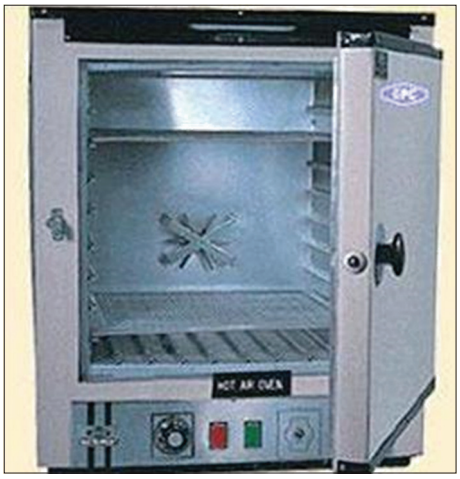

Figure 2: Hot air oven

Figure 3: Bonding material maintained at –10°C

Figure 4: Bonding material maintained at 25°C

Evaluation of the Residual Adhesive

After bond failure, the teeth and brackets were examined under ×10 magnification adhesive remaining after bracket removal was assessed using a modified adhesive remnant index (ARI).

The ARI scale has a range between 5 and 1:

- 5 - Indicating that no composite remained on the enamel;
- 4 - <10% of composite remained on the surface;
- 3 - More than 10% but <90% of the composite remained;
- 2 - More than 90% of the composite remained;
- 1 - All of the composite remained on the tooth, along with the impression of the bracket base.

Statistical Analysis

Basic statistics were calculated for the shear bond strengths of the three groups of teeth. The analysis of variance was used to determine whether significant differences existed between the various groups. Multiple range tests were used to identify which of the groups were different. The Chi-square test was used to determine significant differences in the ARI scores between the different groups.

Figure 5: Bonding material maintained at 45°C

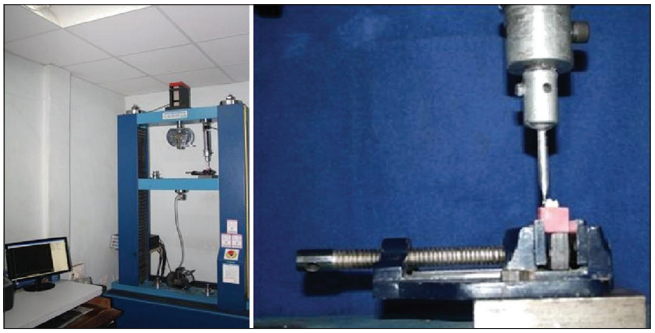

Figure 6: Universal testing machine

RESULTS

The descriptive statistics for the shear bond strength are presented in Tables 1-3.

- Comparison of both the shear bond strengths between the two groups indicated that no significant differences were present between the bonding strength of composite used at −10°C (refrigerated) and that used at 25°C (room temperature).
- As compared with group I and II, there is significant difference were present in the bonding strength of composite used at 45°C (heated).

The test results indicated the presence of a significant difference between the Group I and II. Examination indicated that the group bonded with the refrigerated composite adhesive had a greater ARI score of 4. This indicated that bond failure in this group occurred more frequently at the enamel-adhesive interface. The group bonded with the composite adhesive at room temperature had an increased incidence of ARI score of 2. Indicating that more than 90% of the composite remained on the

Table 1: Shear bond strength of the groups tested

Group I (*n*=15)	Group II (*n*=15)	Group II (*n*=15)
10.9	11.9	14.6
9.8	9.1	12.3
12.3	10.2	17.9
6.1	8.8	19.2
7.8	12.2	14.9
11.8	8.6	16.2
10.2	9.8	11.2
8.7	10.4	17.7
6.3	9.4	21.6
11.2	11.6	20.1
9.4	11.2	11.9
13.2	12.1	13.2
12.6	8.9	14.7
10.05	9.3	15.1
8.1	8.6	9.65

Table 2: Statistics and the result of analysis of variance comparing the shear bond strength of the groups tested

Group tested	*n*	Mean±SD	Variance (SD)
Group I	15	9.89±2.189	4.739
Group II	15	10.14±1.337	1.788
Group III	15	15.35±3.442	11.85

n: Sample size, F ratio: 23.20, *P*: 0.0001. ANOVA: Analysis of variance, SD: Standard deviation

Table 3: Frequency distribution of the adhesive remaining index of the three groups tested

Groups tested	ARI scores					*n*
	1	2	3	4	5	
Group I	7	4	3	1	-	15
Group II	3	2	4	6	-	15
Group III	-	-	4	5	6	15

n: Sample size, *P*: 0.0001. ARI: Adhesive remaining index

tooth. The group bonded with the composite adhesive at high temperature had an increased incidence of ARI score of 3. Signifies less than 10% of the composite remained on the tooth surface.[1]

DISCUSSION

Clinicians face problems during treatment is bracket failure. This is usually the consequence of either a patient's accidentally applying inappropriate force to the bracket or a poor bonding technique. However, the effect of temperature variation on the tensile strength and hardness of composite resin had been also a considering factor during bonding[4] are interested in learning about the properties of the adhesive systems they use so that they can optimize their ability to handle them properly and efficiently. To increase the shelf life of adhesives or to allow for more brackets to be bonded, some manufacturers recommend storing the material in the refrigerator before use. the temperature of the adhesive can vary significantly from patient to patient, depending on the time period between the removal of the bonding kit from the refrigerator (4-5°C) until it reaches room temperature (22-25°C). Present findings indicate that temperature variation affects the composite adhesives which are kept at high temperature range as compared to refrigerated environment or at room temperature. However, due to the exposure of light and heat, composite gets polymerized quickly and the bonding strength affected. Reynolds suggested that a minimum bond strength of 5.9-7.8 MPa was adequate for most clinical orthodontic needs.[5] From a clinical perspective, these findings suggest that the clinician should favor a worm environment before bonding so that strength increases. If applying fairly light forces to the bracket during the ligation of the first archwire after bonding will minimize the incidence of bracket failure at this initial appointment.[6] The evaluation of the ARI scores indicated a significantly higher frequency of bond failure at the enamel-adhesive interface with the refrigerated composite group.[7]

Results of this study can only be used as a guideline in choosing the right adhesive for clinical practice and a sound base for further investigation.[8] It is possible to simulate conditions that are close to those in clinical use, but the potential for unrecognized factors to influence the outcome should always be borne in mind.[9-11] Randomized clinical trials for testing performance of the adhesives in oral environment should be performed in the future to obtain more precise results.

CONCLUSION

The present findings indicate that temperature variation affects the composite adhesive. As compared with refrigerated and room temperature composite, heated composite had high strength. The evaluation of the ARI scores indicated a significantly higher frequency of bond failure at the enamel-adhesive interface with the refrigerated composite group.

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How to cite this article: Girme TS, Bidarkar M, Agrawal J, Agrawal M, Fulari S, Kagi V. Effect of Temperature Variation on Orthodontic Composite: An *In Vitro* Study. Int J Sci Stud 2017;4(12):146-150.

Source of Support: Nil, **Conflict of Interest:** None declared.