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Thermal change assessment in the pulp chamber during orthodontic bonding with different light curing sources (An in vitro study)

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Abstract

Background and objective: Thermal change in pulp chamber with the use of light cured adhesives is one of the contemporary concerns for orthodontists. This study aimed to evaluate intra pulpal temperature rises during bracket bonding using three different light sources.

Methods: Sixty intact-extracted mandibular premolars were divided into three groups of twenty teeth for each. Orthodontic brackets were bonded to the buccal surface of all the teeth with Transbond XT adhesive applying a constant force, first group light cured with halogen light, in second group light emitting diode was used, in third group plasma, arc light was used. The measurements were taken with a J-type thermocouple wire, placed in the center of the pulp chamber and connected to a data plugger.

Results: Statistical analysis showed that temperatures of pulp chamber change were influenced by a type of light source. The intra pulpal temperature changes for halogen was higher than a light emitting diode and both were higher than plasma arc. All the groups revealed a significant difference between each other.

Conclusion: Orthodontic bonding with using different light source did not exceed the critical 5.5° C temperature rise that may induce a thermal change in the pulp.

Keywords: Pulp temperature; Orthodontic bonding; Light cure; Thermal change.

Introduction

The light curing resin adhesives for orthodontic bracket bonding was first used and described in 1979.[1] The light cured resin now become the most popular resin adhesives for most orthodontists because have many advantages; decrease the risk of contamination, accurate bracket placement, extended working time and easier excess adhesive removal after curing.[2] After 1990; scientific breakthrough begins in the sphere of light curing unit; various light units were introduced as an alternative to conventional halogen units.[3-5] During the light activated polymerization of resin adhesive and composites, temperature increases as a result of chemical reaction known as exothermic reaction process and energy absorption during irradiation.[6] According to many authors, the pulp chamber sensitive to physical, chemical, biological and thermal changes; any increase in intra-pulpal temperature exceeding 5°C to 6°C may cause irreversible pulpitis.[7-9] Previous studies have shown the thermal effect of different light-curing units in general dentistry; concluded that heat-induced pulp injury may occur when high-energy light source used with long exposure time.[10-17] The light curing units that were most widely used for photoactivation is halogen light, light emitting diode and plasma arc.[18,19] However, the main question is about the effect of these light curing units on pulp during bracket application. In this in vitro study, we evaluated the temperature rise in the pulp chamber during bracket bonding by using different light curing units.

Methods

Sixty intact-extracted mandibular

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premolars for orthodontic reasons were used in this study. Teeth of same homogenous size and volume were used to provide a similar thickness of tooth structure and ensure similar distance from the pulp chamber to the surface of the tooth by the aid of micro-computed tomography. After micro-CT evaluation, teeth with abnormally large or small pulp chamber and teeth with extremely thick or thin enamel or dentin were excluded from this study. The teeth were divided into three groups of 20 teeth each. The root portion was sectioned with diamond disks approximately 2mm below the cement-enamel junction perpendicular to the long axis of the tooth. The access opening into the pulp chamber was enlarged by Gate Glidden drill as needed to ensure insertion of the thermocouple wire without resistance. The pulp chamber was cleaned of remaining pulp tissues with an excavator and 6% sodium hypochlorite application for 2 minutes, after that the pulp chamber were rinsed with distilled water for 5 minutes and air-dried. All the teeth (Enamel surface) were etched for 45 seconds with 37% phosphoric acid (3M Unitek, USA), then rinsed with water for 30 seconds, and dried with oil-free air for 20 seconds. Stainless steel orthodontic brackets (Roth, 0.22) (3M Unitek, USA) were bonded to the buccal surface of all teeth with Transbond XT (3M Unitek, USA) adhesive; applying a constant force with the help of a surveyor, excess composite was gently removed before curing and light cured with 3 different light units (Table 1). The curing was done as follows, group 1; HQTH unit used for 40 seconds 20 teeth, group 2; LED unit used for 20 seconds 20 teeth, group 3; Plasma arc units for 5 seconds 20 teeth, according to the manufacturing instruction of each light. The outputs of light tips from curing light units were measured by using a digital curing radiometer. The distance between the tip of the light source and tooth surface was 2 mm. For temperature measurement a J-type thermocouple wire of 0.36-in diameter (Omega Engineering, Stamford, Conn) was connected to a data logger during the light curing procedure, to facilitate the transfer of heat from the walls of the pulp chamber to the thermocouple a silicon heat transfer compound was injected into the pulp chamber. Before temperature measurements were made, the position of the thermocouple was verified by using radiographs and corrected as needed in such way the wire touched the center region of the roof of the pulp chamber. Specification accuracy was maintained without user changes. The manufacturer reported a temperature accuracy of ± 0.15° C from 0°C to 40°C. The collected data were monitored and transfer to a computer. Temperature variation was measured for each group; as the change from baseline temperature to the highest or lowest temperature recorded after various light curing procedures, a negative temperature value indicated a decrease in pulp temperature whereas a positive temperature variation value indicated an increase in the pulp chamber. Temperature changes were calculated and averaged to determine the mean value in temperature rise. A temperature increase of 5.5°C considered as a baseline value above which cause pulp damage.[7-9] Analysis of variance (ANOVA) and Tukey's HSD was used to determine the effect of light curing unit on temperature change between the groups at the significant level of $P \leq 0.01$.

Table 1: Light sources used in this study.

Light curing unit	Manufacturer	Diameter of tip (mm)	Power intensity (mW/cm^2)	Exposure time (s)
Optilux 501	Kerr, Danbury, conn	8	850	40
Ortholux LED	3M, Monorovia,Calif	8	1100	20
Power PAC Plasma	ADT, San Carlos, Calif	7	1200	5

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Results

The descriptive statistics for each experimental group are shown in Table (2). The highest thermal change was recorded in-group one HQTH (4.11 ± 1.24) followed by LED and Plasma arc respectively. One-way ANOVA analysis (Table 3). showed that there is a significant difference among groups at the level of P <0.001. According to the Tukey's HSD test (Table 4) group, three presented a significantly lower temperature change value compared to group one and two.

Table 2: Thermal change in pulp chamber for three light sources.

Light curing unit	No.	Mean	SD	Min.	Max.
Optilux 501	20	4.11	0.85	2.87	5.35
Ortholux LED	20	2.30	0.80	1.38	3.22
Power PAC Plasma	20	0.90	0.68	0.30	2.51

Table 3: ANOVA analysis for three light curing source.

	Sum of Squares	df	Mean Square	F	*P* value
Between Groups	103.908	2	51.954	117.610	<0.001
Within Groups	25.180	57	.442		
Total	129.088	59			

Table 4: Tukey's HSD test group three presented a significantly lower temperature change value compared to group one and two.

(I) factor	(J) factor	Mean Difference (I-J)	Std. Error	*P* value	99% Confidence Interval	
					Lower Bound	Upper Bound
ptilux	ortholux	1.86000*	.21018	<0.001	1.2223	2.4977
	power PAL	3.21000*	.21018	<0.001	2.5723	3.8477
ortholux	ptilux	-1.86000*	.21018	<0.001	-2.4977	-1.2223
	power PAL	1.35000*	.21018	<0.001	.7123	1.9877
power PAL	ptilux	-3.21000*	.21018	<0.001	-3.8477	-2.5723
	ortholux	-1.35000*	.21018	<0.001	-1.9877	-.7123

* The mean difference is significant at the 0.01 level.

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Discussion

When the scientific development combined with tremendous innovation, much new high-intensity curing units were brought to the markets. The high-intensity light curing units are important for the adequate polymerization of the orthodontic composite. Problems associated with inadequate polymerization include inferior physical properties, solubility in the oral environment; increased microleakage and bonding failure. On the other hand, high-intensity light curing units must be used with extreme care to avoid harm to the dentin-pulp complex.[20] In this in vitro study, we evaluated temperature change during polymerization of an orthodontic bonding adhesive system by using three commercially light curing units. To simulate clinical condition the premolar teeth used with similar features for standardization and accuracy with repeatability similarity in size, volume, and thickness of enamel and dentin determined by the aid of micro-computed tomography. Because the thermal effect on the pulp tissue depends on many factors one of them enamel and dentin thickness.[21,22] Thermocouples were selected to determine temperature change during the polymerization of adhesive system because of accuracy and reliable reading that previously demonstrated with this technique in conservative and prosthetic dentistry.[23-26] The important factor for temperature rise light activated polymerization of resin composite was the amount of energy absorbed during polymerization. The energy absorption primarily depends on the intensity and duration of applied thermal stimuli which are light curing units.[27] The following study showed a statistically significant difference among three groups; the HQTH group with longest exposure time induced significantly higher intra-pulpal temperature changes than other groups. However; the critical values (5.5° C) were not exceeded in all groups. The total light energies that were applied into the tooth calculated by (light intensity X exposure time); for group of HQTH (850X40 = 34000 mW/cm^2), for LED group (1100X20 = 2200 mW/cm^2), for Plasma arc group (1200X5 = 6000 mW/cm^2). Accordingly, the plasma arc has markedly reduced curing time and light energy this might be the possible reason for why the plasma arc-induced less intra-pulpal temperature changes than other groups. The mean amount of time required for thermal energy to transfer to the pulpal tissue was less. Tarle et al. and other studies reported the same results that Plasma light leads to lower temperature rise than Halogen and LED. They showed that high power light cure develops significant temperature rise on the surface of the tooth which cannot be transferred as a result of short curing time.[28] Various studies have showed that the possible adverse effect of recorded temperature change in the pulpal tissue is irreversible pulpitis. All curing unit produced temperature change under the critical level that causes irreversible pulpitis.[29-31]

Conclusion

Orthodontic bonding with using different light source did not exceed the critical 5.5° C temperature rise that may induce a thermal change in the pulp.

Conflicts of interest

The authors report no conflicts of interest.

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