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In-vitro determination of residual monomer leaching by high performance liquid chromatography: light emitting diode versus halogen light

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Abstract

Introduction: The long life span of light emitting diode (LED) and more consistent light output compared with halogens has resulted in greater use of LED in Orthodontics. Aim of present research was to compare the mean residual monomer (RMo) released from composites cured with LED or halogen lights.

Material and Methods: This in-vitro study was conducted at Department of Orthodontics, de'Montmorency College of Dentistry, Lahore. 150 extracted teeth were randomly divided into 2 groups of 75 teeth each, by lottery method. The selected teeth were cleansed of any debris, rinsed in distilled water and were stored in distilled water container. All teeth were embedded in cold cure fast set acrylic resin jig. In group 1, teeth brackets were cured with LED light source and in group 2, by halogen light. High performance liquid chromatography (HPLC) was used for estimating the mean amount of RMo release. Independent t-test was used for comparison of mean release of RMo in both groups. Level of significance was determined at $p \leq 0.05$.

Results: The mean value of RMo leaching was statistically greater in adhesives cured with halogen light group (94.67±3.13 ppm) then the LED source group (37.91±1.86 ppm). (P = 0.012)

Conclusions: LED lights are recommended in Orthodontic practice as the residual monomer leaching was significantly less as compared to the halogens.

Keywords: Residual monomer; bisphenol A; light emitting diode; halogen

Introduction

Glass Ionomer Cement, Poly-acrylates and Resin-Modified Glass Ionomer Cements are normally used orthodontic adhesives but nowadays Composite Resins are commonly used for bonding orthodontic brackets.[1] Composite resins are composed of dimeth-acrylates like Bis-GMAs and inorganic filler particles like silica.[2] Composite resins are of 2 types; light cured and chemical cured composites, but light cured composites are mostly suggested for bonding orthodontic brackets.[3]

Conventional Halogen light, Plasma arc light, Argon laser and Light emitting diodes (LED) are available light source units.[4,5] LED lights are junctions of doped semiconductors and have advantages of lower energy consumption, longer life, improved physical robustness, smaller size and faster switching.[6] Conventional halogen unit produces light by heating a tungsten filament and produces required blue light by filtration. It has the disadvantages of limited life, decreased curing efficiency and bulb degradation issues. Polymerization of resin usually starts when a light of wavelength 400-520 nm is used with light intensity of 300 mW/cm^2.

Residual monomer (RMo) leaching is a well established phenomenon that can lead to several negative biomechanical effects such as poor bond strength, increased rate of water sorption, solubility, degradation, abrasive

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instability and high toxicity to pulp. Biological side effects include estrogenic effects, mutagenic effects, hypersensitivity reactions and color blindness.[7-9]

RMo amount can be measured by direct and indirect methods. Indirect method includes high performance liquid chromatography (HPLC), and micro-hardness. Direct methods include Spectroscopy and Fourier Transform Infrared Spectroscopy.[10] Literature[11] on the subject matter reveals that RMo amount was 195.68±1.43 ppm and 198.45±1.48 ppm with halogen light and LED light, respectively.

Rationale of present research was to minimize the RMo by choosing the better curing light thus minimizing the physical and hazardous biological effects of free monomers. Data is published in this regard but results may differ in the present study because previously conducted studies were on bovine teeth and not on human teeth. There are certain differences in human and bovine teeth.[11,12]

Objective of the present study was to compare the mean RMo release from adhesives under the orthodontic brackets cured with LED or Halogen light sources. Our hypothesis was that there is no difference in RMo release from adhesives cured with either of the light sources.

Material and Methods

In-vitro, comparative study was conducted at Department of Orthodontics, de'Montmorency College of Dentistry, Lahore. Sample size of 150 extracted teeth was estimated using 95% confidence level, 80% power of test with an expected mean RMo release in halogen group as 196.68±1.43 ppm and in LED group as 198.45±1.48 ppm.[11]

Following teeth were selected: maxillary / mandibular bicuspids with intact buccal surface. Teeth with dental pathology involving buccal surface and history of orthodontic treatment were excluded from the sample.

150 bicuspids extracted for Orthodontic reasons, were preserved in 0.1 % thymol solution. They were divided randomly into 2 groups of 75 teeth each, by using lottery method. Group 1 included teeth with brackets cured with LED light and Group 2 included teeth having brackets cured with halogen units. The distance of light curing tip was kept at a minimum in both groups i.e. 0 mm. The selected teeth were cleansed of any debris, rinsed in distilled water and stored in black plastic container for a day. All teeth were embedded in cold cure fast set acrylic jig. The teeth were initially cleansed and rinsed with water for 15 seconds, and then air dried. Each tooth was etched with 37% phosphoric acid gel for 30 seconds followed by rinsing with water for 30 seconds and then air dried. Trans-bond XT primer (3M-Unitek, St Paul, Minnesota, USA) was applied; air thinned and light cured for 20 seconds. Premolar brackets (Discovery, Dentaurum, Germany) were taken and bonded to the buccal surface using Trans-bond XT adhesive paste (Trans-bond XT, 3M Unitek, Monrovia, Calif). The bonding was performed in the same environment to prevent different luminous densities. After bonding, the samples were stored for a day in an incubator to simulate thermal environment of oral cavity.

The procedure used for measuring the amount of RMo leaching was similar to that described by Eliades et al.[13] Confounding variables were controlled by strictly following the selection criteria. RMo was measured by expert orthodontist.

Data was analyzed using SPSS software (version 20.0). Quantitative date mean measurement of RMo release was presented by mean ±SD (in ppm). Independent t-test was used for comparison of mean release of RMo in both the groups. The level of significance was determined at $p \leq 0.05$.

Results

150 extracted premolars were included in this study (Table I**)**. The mean RMo leaching was 96.29 ± 3.03ppm (Table II)**.** The mean RMo

leaching in halogen group was 94.67 ± 3.13 ppm whereas in LED group it was 37.91±1.86 ppm. Thus statistically significant difference was found between the study groups for RMo released amount (Table III).

Table I: Descriptive statistics of two groups

		Frequency	Percent
Curing Technique	Halogen light	75 teeth	50.0%
	LED light	75 teeth	50.0%
	Total	150 teeth	100.0%

Table II:Descriptive statistics of mean residual monomer leaching (ppm)

Residual Monomer (ppm)	N	150 teeth
	Mean	96.29
	SD	3.03
	Minimum	30
	Maximum	120

Table III: Comparison of two groups

		Curing Technique	
		Halogen light	LED
Residual Monomer (ppm)	N	75	75
	Mean	94.67	37.91s
	SD	3.13	1.86

p-value = 0.012 (Significant)

Discussion

There are several curing light units one can choose from for bonding orthodontic brackets.[14-15] As far as RMo release is concerned, several factors play their part such as, type of light curing, curing time, curing light tip distance and intensity of curing light.[16] Results of current study are important because kuppi[8] showed that unpolymerized adhesive should be avoided as it has been implicated in bond failure, several negative biomechanical and alarming biological side effects.[17]

This in-vitro comparative study was conducted to determine the mean RMo released from adhesives cured with LED or Halogen light. According to the results, there was a significant difference between the two groups in leaching of residual monomer with mean value of RMo of Halogen group as 94.67 ± 3.13 whereas the mean value of RMo of LED group was 37.91 ± 1.86. This could have happened because of slow and incomplete polymerization by low intensity halogens and may also be due to the fact that LED have high light energy, high luminous intensity, narrower spectral distribution and good absorption.[18]

Results are in contrast with previous laboratory studies on the bond strength of brackets cured with LED that reported no statistically significant differences between conventional light and LED light.[19-21] Our findings are in agreement with a previous study[11] but that was done on bovine incisors. There are certain differences in human and bovine teeth, such as average diameter of enamel crystallite of bovine is larger, calcium content is higher, micro leakage is more and radiographic enamel density of bovine enamel is more than human teeth.[12]

Our results are comparable with previous comparative studies between the two light sources with reference to the bond strength. Results reported by Wendle show that halogen yields stronger bonds than does LED.[22] It is possible that these results reflect the use of powerful halogens as compared to first-generation LED units.[23] Cacciafesta introduced a new model of LED and compared it with halogen. Although LED use resulted in greater bond strength, the difference was not significant.[11] Thind et al. concluded that there was no difference between the ARI scores produced by the conventional Tungsten-Quartz-Halogen and LED light sources.[24] Sfondrini et al. concluded that Light-curing for only 2 seconds with the micro-xenon light does not preclude clinically acceptable bond strengths of both uncoated and pre-coated metal brackets. When cured with the conventional HLC unit, uncoated brackets produce significantly higher shear bond strengths than those of the pre-coated brackets.[25]

One shortcoming of the current study was that it was conducted in in-vivo environment,

which cannot reproduce the in-vitro oral conditions. Clinically, intraoral contamination, saliva, thermal changes and other factors such as occlusal forces and orthodontic forces can influence release of RM. Despite this shortcoming, the result of the current study suggests that LED should be used instead of halogen units while bonding orthodontic brackets to avoid minimal release of residual monomers.

Conclusions

LED light units are recommended in clinical orthodontic practice as residual monomer leaching is significantly less as compared to the halogen light units.

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