Temperature changes on dental pulpal chamber during Led light curing simulation

Pereira TM[1], Zezell DM[1], Gomes MN[2], Devito-Moraes AG[2], Moraes RR[2], Froes-Salgado NRG[2], Franci CE[2].
1 - Centro de Lasers e Aplicações - Instituto de Pesquisas Energéticas e Nucleares CNEN/ SP - Brasil
2 - Materiais Dentários – Universidade de São Paulo.

RESUMO

Um procedimento rotineiro em clinica odontológico é a restauração em resina de cavidades profundas proximas à pulpa dental. A polpa dental é sensível a aumentos de temperatura maiores que 5,5 °C, após a qual entra em processo de necrose. O *objetivo do presente estudo foi medir o aumento da temperatura no interior da câmara pulpar, devido à irradiação de diferentes LED para simular uma condição clínica de fina camada de dentina acima da polpa. Quinze LED comerciais foram utilizadas no presente estudo. Cento e setenta dentes bovinos foram extraídos e limpos. As amostras foram igualmente divididas em 15 grupos de acordo com a fonte de iluminação. As cavidades classe V foram preparadas até chegar a uma espessura de dentina remanescente de aproximadamente 1 mm e irradiada durante 40 s. A temperatura no lado oposto da cavidade foi gravado por uma câmera infravermelha (FLIR, SC, 3000) a 60 Hz. A gravação começou 10s antes e continuou até 10s após o final da irradiação. A análise estatística foi realizada pela ANOVA e teste de Tukey (p = 0,05) utilizando a média de valor de aumento da temperatura de cada grupo. O LED (UB) mostrou a elevação da temperatura mais baixa 2,82 ± 0,99 ° C, enquanto que a Smart Lite, Dentsply e Ivoclar (PA) apresentaram os maiores valores de 11,25 ± 1,27 ° e C (PA) 10, 64 ± 1,13 ° C, respectivamente. Os resultados sugerem que há uma grande variação do resultado obtido durante a foto polimerização.vários deles mostraram um aumento de temperatura maior que 5,5 °C (o limite de segurança para a polpa) Um dos fatores que contribuem para isto é falta de uma regulamentação da ANVISA sobre a fabricação e comercialização deste tipos de equipamento biomédico.*

Descritores: laser, odontologia, temperatura.

ABSTRACT

The restoration of deep cavities using resin close to dental pulp is a common procedure in the clinical dentistry. The pulp is sensitive to temperature increases more than 5.5 °C, after which they enter into the process of necrosis. The goal of the present study was to measure the increase in temperature inside the pulp chamber due to the different LED irradiation to simulate a clinical condition of thin dentin layer above the pulp. Fiveteen commercial LED were used in the present study. One hundred seventy bovine teeth were extracted and cleaned. The samples were equally divided into 15 groups according to lighting source. The class v cavities were prepared until reaching a remaining dentin thickness of 1 mm and irradiated during 40 s. The temperature at the opposite side of cavity was recorded by an infrared camera (FLIR, SC 3000) at 60 Hz. The recording started 10s before and continued until 10s after the end of irradiation. Statistical analysis was performed by ANOVA/Tukey test (p =0.05) using the mean of increase temperature value from each group. The LED (UB) showed the lowest temperature elevation 2,82 ° C ± 0,99, while the Smart Lite, Dentsply and Ivoclar (BP) showed the highest values 11,25 ± 1,27 ° C e (BP) 10,64±1,13 ° C respectively. The results suggest that there is a wide variation of results obtained during the photo-polymerization. Several of them showed higher temperature increase than 5,5 °C (the limit of safety temperature for the pulp vitality). One of the factors contributing to this is lack of regulation of ANVISA on the manufacture and marketing of these types of biomedical equipment.

Key words: Dentistry, laser, Temperature

INTRODUCTION

Dental restorative processes are used to decrease the polymerization periods of resin composite and minimize its polymerization shrinkage. During these processes, teeth are exposed to the radiation of light curing units (e.g., halogen polymerization lamps or semiconductor diode light) and experience substantial temperature increase of 10-18 ºC within the resin and adjacent tooth and 2–9 ºC at pulpal chamber wall [1].

There is a controversial discuss about what is the critical temperature increase hazardous for the pulp. Since 1965, temperature increase within the pulp chamber of 5.5 cause irreversible hazardous into the teeth [2]. A study on the temperature increase in teeth, however, states that a temperature increase of 11,2 graus Celsius does not damage the pulp [3].However another study on living dental pulp of rats showed that when the temperature was kept at 46 – 50 graus Celsius for 30s, statis and trombosis developed leading to a standstill of circulation [4].

MATERIAL AND METHODS

The lingual faces of 150 bovine incisors were removed. Standard Class V cavities (2.5 mm wide by 3 mm long) were prepared 1 mm above the cemento-enamel junction in the buccal faces using water-cooled MF 3099 diamond cylindrical burs (KG Sorensen, Barueri, SP, Brazil) in high speed. Burs were replaced every four preparations. The depth of the cavity was controlled in order to standardize a 1 mm dentin thickness in the pulpal floor of all cavities. The samples were equally divided into 15 groups according to following lighting source: Smart Lite, Dentsply (SL); Radii Plus, SDI (RP); Elipar Freelight 2, 3M ESPE (EP);LE Demetron, Demetron (LD); Celalux, Voco (CL); Ultralume 5, Ultradent (UT); Bluephase G2, Ivoclar (BP); Flashlite, Discus (FL); Ultralight III, Sanders (UL); LEC 470II, MM Optics (LE); Biolux, Bioart (BL); Ultra Blue, DMC (UB); Blue Star, Microdont (BS), Mais, New Image (MS) e Demi, Kerr (DM).

Temperature in the pulpar wall region was measured by infrared thermographic (ThermaCAMSC 3000; FLIR Systems Inc., Boston, MA, USA) with a sensitivity of 0.01°C and response time of 0.01s.

The thermography camera was positioned in the pulp area through the exposed lingual face of the teeth at a distance of 10 cm between the sample and camera. The camera was calibrated considering the dentin emissivity to be 0.91 within the temperature range of 20 to 100°C, with data acquisition at 60 Hz. Measurements were carried out under controlled temperature (25 °C) and humidity (45%) conditions. The LED units were placed in contact with the buccal aspects of the teeth and light exposure was carried out for 40 s (n=10). Data were processed using the software ThermaCAM Research 2001(FLIR Systems Inc.) to determine the maximum temperature rise in the pulpar floor.

RESULTS

The rise temperature mean of the each commercial LEDs used in this study are shown in figure 1.

DISCUSSION

Infrared camera was used to evaluate pulpal wall temperature increase. This technique is more accurate than thermal couples technique, When thermal couples are used, the imperfect contact between the probe and tooth structure (e.q., existence of air gap) increase the measurement error.

The tooth absorption coefficient is low for the wavelengths used in this study $400<\lambda<500$ ηm, thus scattering predominates over absorption [5] that leads to photons being absorved far away from the irradiated surface. According to the modified Beer Lambert Law and diffusion theory, the light intensity

exponentially decreases as function of deep, thus the surface temperature is higher than internal temperature. The temperature increase is higher at closer distances [6].Nervertheless, the absorption of the scattered photons in deeper layers can results in temperature rises that are harmful to the pulp.

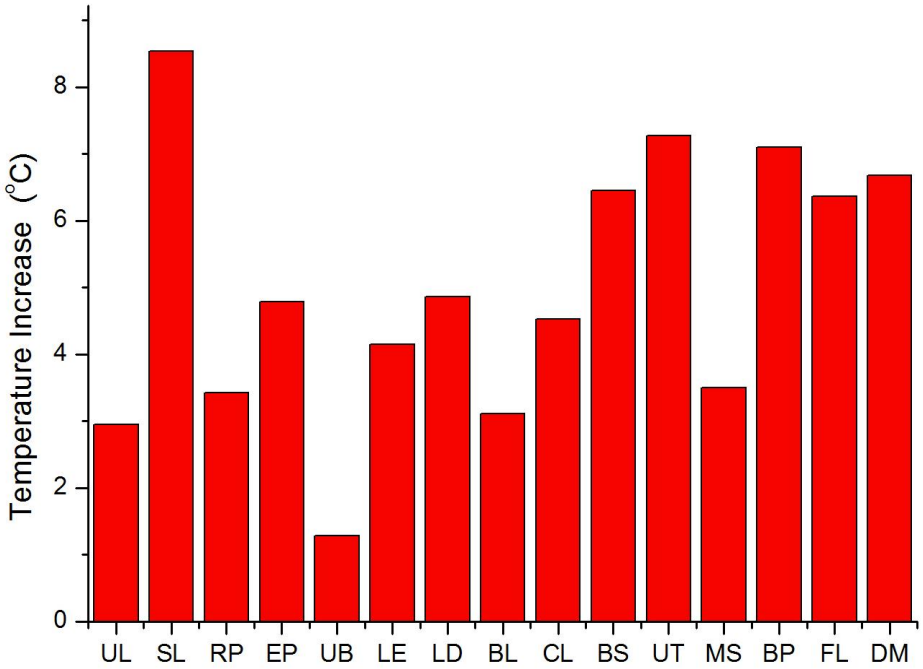

Figure 1: average temperature rise of the LEDs used in this study.

Enamel and dentine have different thermal properties. The most important thermal properties when the heat transfer in tooth is thermal diffusivity. The thermal diffusivity for human enamel and dentin are 4,69 and 1,86 cm^2/s respectively. The difference in this properties may result in thermal stresses and cracking within tooth when subjected to thermal stimulus[7,8].

The light curing devices: Smartlite,Bluephase,Ultralume LED5, Flashlite, BlueStar, Optilux 501 are more probable to induce a pulpal damage if a long radiant exposure were irradiated on a thin pulpal wall.

In this study all measurements were done on ambient with air-conditioning. Previous studies have shown that infrared thermographic analysis is highly dependent on ambient room conditioning [9]. In-vivo the baseline temperature may be higher than the temperature o bovine tooth. The tooth surface temperature measured using a thermistor range of 30 ºC – 34.4 ºC for maxillary lateral incisor (49).

CONCLUSION

The results showed that irradiation depends on the irradiance, that is not same for different manufacturer because a lack of regulatory recommendation from ANVISA. Several photo-polymerization showed higher temperature increase than 5,5 °C (the limit of safety temperature for the pulp vitality).

Nois quais foram medidos temperaturas acima dos valores de segurança para vitalidade pulpar.

ACKNOWLEDMENT

FAPESP CEPID (05/51689-2), Rede de Nanofotônica - MCT/CNPq (555170/2005-5), Instituto Nacional de Fotônica – INFO/CNPq (573916/2008-0).

REFERENCE

[1] Campregher UB, Samuel SM, Fortes CB, Medina AD, Collares FM, Ogliari FA. Effectiveness of second-generation light-emitting diode (LED) light curing units. J Contemp Dent Pract. 2007;8(2):35-42.

[2] Stahl F, Ashworth SH, Jandt KD, Mills RW. Light-emitting diode (LED) polymerisation of dental composites: flexural properties and polymerisation potential. Biomaterials. 2000 Jul;21(13):1379-85.

[3] Mills RW, Uhl A, Blackwell GB, Jandt KD. High power light emitting diode (LED) arrays versus halogen light polymerization of oral biomaterials: Barcol hardness, compressive strength and radiometric properties. Biomaterials. 2002 Jul;23(14):2955-63.

[4] Ozturk B, Ozturk AN, Usumez A, Usumez S, Ozer F. Temperature rise during adhesive and resin composite polymerization with various light curing sources. Oper Dent. 2004 May-Jun;29(3):325-32.

[5] Niemz MH. Laser-tissue interactions: fundamentals and applications. 3rd ed., Berlin: Springer, 1997.

[6] Hannig M, Bott B (1999). In-vitro pulp chamber temperature rise during composite resin polymerization with various light-curing sources. Dent Mater 15(4):275-81.

[7] Aguiar FH, Braceiro AT, Ambrosano GM, Lovadino JR. Hardness and diametral tensile strength of a hybrid composite resin polymerized with different modes and immersed in ethanol or distilled water media. Dent Mater. 2005 Dec;21(12):1098-103.

[8] Knezevic A, Tarle Z, Meniga A, Sutalo J, Pichler G, Ristic M (2001). Degree of conversion and temperature rise during polymerization of composite resin samples with blue diodes. J Oral Rehabil 28(6):586-91.

[9] Millar BJ, Nicholson JW (2001). Effect of curing with a plasma light on the properties of polymerizable dental restorative materials. J Oral Rehabil 28(6):549-52.