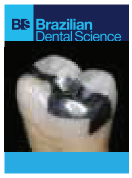
Brazilian Dental Science
Ciência Odontológica Brasileira
unesp
UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"
Instituto de Ciência e Tecnologia
Campus de São José dos Campos



ORIGINAL ARTICLE
doi: 10.14295/bds.2015.v18i1.1086

Intra pulp chamber temperature variation caused by Nd:YAG and Diode LASER irradiation

Variação da temperatura intracâmara pulpar provocada pela irradiação com laser de Diodo e Nd: YAG

Sérgio Kiyoshi ISHIKIRIAMA[1], **Rafael Massunari MAENOSONO**[1], **Leticia Ferreira de Freitas BRIANEZZI**[1], **Vanessa Maira Vieira CUNHA**[2], **Rafael Francisco Lia MONDELLI**[1]

1 – Department of Operative Dentistry, Endodontics and Dental Materials – Bauru School of Dentistry – University of São Paulo – Bauru – SP – Brazil.

2 – Bauru School of Dentistry – University of São Paulo – Bauru – SP – Brazil.

ABSTRACT

Objective: Neodymium (Nd:YAG) and Diode LASER irradiation on adhesive systems canincrease bond strength to dentin, however, concerns about the temperature variation inside pulp chamber still remain. The aim of this study was to evaluate the intra pulp chamber temperature variation caused by irradiation with Nd:YAG or Diode LASER on different adhesive systems. **Material and Methods:** This study presented experimental design with two factors: LASER on two levels (Diode [D] and Nd:YAG [N]) and adhesive system on four levels (Adper™ Scotchbond™ Multi-Purpose [MP], Adper™ SingleBond 2 [SB], Clearfil™ SE Bond [CSE] and Adper™ Easy One [EO]). The quantitative response variable was the temperature variation (Δt) in ºC. Forty bovine teeth, distributed into 8 groups (n = 5), had the buccal surface flattened up to1 mm thickness of dentin. After the application of each adhesive system, but previously to the light curing, specimens were irradiated with Nd:YAG or Diode LASER with standardized parameters. The Δt was obtained through a thermocouple inserted into pulp chamber. The values of Δt were submitted to two-way ANOVA, followed by Tukey ($p < 0.05$) for individual comparisons. **Results:** The means (± standard deviation) of Δt were: N-MP: 12.60 (± 2.51), N-SB: 10.40 (± 5.03), N-CSE: 11.80 (± 5.12) and N-EO: 10.20 (± 2.39), D-MP: 4.4 (± 1.82), D-SB: 5.20 (± 1.54), D-CSE: 4.60 (± 1.14), D-EO: 3.60 (± 1.52). **Conclusion:** The type of adhesive system was not significant in temperature changes generated by LASER irradiation, but Nd:YAG LASER may provide a higher potential to cause pulp damage.

KEYWORDS

Dental Pulp; Lasers; Dentin-Bonding Agents.

RESUMO

Objetivo: A irradiação com LASER de Neodímio (Nd:YAG) e de Diodo sobre sistemas adesivos pode aumentar a resistência de união em dentina, no entanto a existe a preocupação com a variação de temperatura intracâmara pulpar. O objetivo deste trabalho foi avaliar a variação da temperatura intracâmara pulpar após a aplicação dos sistemas adesivos e subsequente a irradiação com LASER de diodo e Nd:YAG. **Material e Métodos:** Este estudo apresentou um desenho experimental fatorial com dois fatores: LASER em dois níveis (Diodo [D] e Nd:YAG [N]) e sistema adesivo em quatro níveis (Adper™ Scotchbond™ Multi-Purpose [MP], Adper™ SingleBond 2 [SB], Clearfil™ SE Bond [CSE] e Adper™ Easy One [EO]). A variável de resposta quantitativa foi a variação da temperatura (Δt) em ºC .Utilizou-se 40 dentes bovinos, separados em 8 grupos (n=5), a superfície vestibular foi desgastada até 1 mm de espessura. Depois da aplicação de cada sistema adesivo, mas previamente a fotopolimerização, os espécimes eram irradiados com LASER de diodo e Nd:YAG com parâmetro padronizados. A Δt foi obtida com um termopar inserido intracâmara pulpar. Os valores obtidos foram submetidos ao teste ANOVA a 2 critérios seguido de Tukey para comparações individuais($p<0,05$). **Resultados:** A média e o desvio padrão da Δt obtidos foram: N-MP: 12.60 (± 2.51), N-SB: 10.40 (± 5.03), N-CSE: 11.80 (± 5.12) e N-EO: 10.20 (± 2.39), D-MP: 4.4 (± 1.82), D-SB: 5.20 (± 1.54), D-CSE: 4.60 (± 1.14), D-EO: 3.60 (± 1.52). **Conclusão:** O tipo de sistema adesivo não foi significante no aquecimento gerado pela irradiação com LASER, mas o LASER de Nd:YAG pode fornecer um potencial maior para causar danos a pulpar.

PALAVRAS-CHAVE

Palavras-chave: Polpa Dentária; Lasers; Adesivos Dentinários.

INTRODUCTION

The use of LASER in dentistry has increased in many areas [1-4], especially in restorative dentistry, due to growing knowledge of LASER interaction with dental structures [5-8]. Despite these advances, when new LASER irradiation technique is proposed, temperature variation in pulp chamber should be considered, and some investigations are needed prior to clinical use. [9,10-12]

Recently, a new technique of LASER irradiation was proposed to improve adhesion obtained between dentin and adhesive systems [13]. This technique, which consists of Nd:YAG LASER irradiation on adhesive systems already applied on dentin, however prior to light curing, has obtained favorable results with increased bond strength [14,15] and reduced dentin microleakage [16]. Maenosono et al. [17], using similar technique, using a Diode LASER (970 nm) instead, also observed significant increase in bond strength of simplified adhesive systems to dentin.

Despite the favorable results, the parameters used for LASER irradiation are quite different among other reported techniques and again, the concern with temperature variation to the pulp organ should be considered. The present study aimed to assess the intra pulp chamber temperature variation caused by irradiation of different adhesive systems with Nd:YAG and Diode LASERs.

MATERIAL AND METHODS

I. EXPERIMENTAL DESIGN

The present in vitro study evaluated two variation factors: LASER in two levels (Nd:YAG [N] and Diode [D]) and adhesive system in four levels (Adper™ Scotchbond™ Multi-Purpose [MP], Adper™ SingleBond 2 [SB], Clearfil™ SE Bond [CSE] and Adper™ Easy One [EO]) (Table 1). The quantitative response variable is the temperature variation (Δt) in °C, measured by a digital thermocouple (MTK-01, Minipa, Shanghai, China).

Table 1 - Chemical composition of the used adhesive systems, according to the manufacturers.

MATERIAL	COMPOSITION
Adper™ Scotchbond Multi-Purpose Plus 3M ESPE, St Paul, EUA	Primer: HEMA, polyalkenoic acid polymer, water Adhesive: Bis-GMA, HEMA, tertiary amines (both for light-cure and self-cure initiators), photo-initiator
Adper™ Single Bond 2 3M ESPE, St Paul, EUA	Bis-GMA**, HEMA*, Dimetacrilatos, Etanol, Water, Photo-initiator, Methacrylate functionalized polyacrylic and polyalkenoic acid
Clearfil™ SE Bond Kuraray, Osaka, Japan	Primer: MDP, HEMA, hydrophilic dimethacrylate, photo-initiator, water Adhesive: MDP, HEMA, Bis-GMA, hydrophobic dimethacrylate, photo-intiators, silanated colloidal silica
Adper™ EasyOne 3M ESPE, St Paul, EUA	HEMA, Bis-GMA, Methacrylated phosphoric esters 1,6 hexanediol dimethacrylate, methacrylate functionalized polyalkenoic acid and camphorquinone

II. SPECIMEN PREPARATION

The sample consisted of 40 bovine incisors, cleaned and stored in thymol solution (0.1%) until specimen's preparation. A coronary opening in the palatal surface was initially performed with high-speed handpiece and a diamond tip (1016 HL, KG Sorensen Medical Burs, Cotia, SP, Brazil). The buccal surface was flattened in a polishing machine (Aropol-2V, Arotec, Cotia, SP, Brazil) with silicon carbide sandpaper, with 320 and 600 grit (Carbimet Paper Discs, Buehler, Lake Bluff, IL, USA) at low speed and water cooling, obtaining a simulated smear layer. The remaining buccal dentin thickness was standardized in 1 mm.

In order to standardize the area of LASER irradiation, a 6 x 6 mm silicone matrix (Zetalabor, Zhermack, São Paulo, Brasil) was positioned in the center of flattened surface and the test area was delimited with nail polish, comprising 36 mm2. The teeth were then stored in deionized water at room temperature until the LASER irradiation protocol.

III. TEMPERATURE VARIATION TEST

The specimens were treated in accordance to respective adhesive system of their groups, and prior to light curing they were irradiated with Nd:YAG LASER (Smartfile, Deka, Calenzano, Italy) or Diode LASER (SiroLaser, Sirona Dental Systems, Benshein, Germany). The irradiation was carried out with the optic fibers in contact mode, perpendicular to flattened surface, using same parameters for both LASERs (Table 2). After each irradiation, a small portion of optic fiber endpoint was cut to eliminate residues of adhesive system.

The intra pulp chamber temperature variation (Δt) was recorded with digital thermometer (MT401A, Minipa, Shanghai, China) linked to a universal type K thermocouple (MTK-01, Minipa, Shanghai, China), positioned internally to pulp chamber, in contact to inner buccal dentin (Figure 1). The remaining pulp chamber spaces were filled with a white thermal paste (Implastec, Votorantim, São Paulo, SP, Brazil). After the thermocouple positioning, the lingual surface was isolated with black eletrical tape (3M Brazil, SP, Brazil). LASER irradiation was performed by a single operator.

Table 2 - Parameters used for the irradiation test area with LASER

Parameter	Value
Energy per pulse	80 MJ
Frequency	10 Hz
Power	0.8 W
Beam cross-sectional area (diameter of 200 μm)	3.14×10^{-4} cm^2
Irradiated Area	36 mm^2
Irradiation Time	30 s
Energia Total	24 J
Power Density	2547.77 W/cm^2
Energy Density	66.67 J/cm^2

IV. STATISTICAL ANALYSIS

The values of Δt were submitted to two-way ANOVA, followed by Tukey test for individual comparisons ($p < 0.05$).

RESULT

The average and standard deviation of Δt observed during LASER irradiation for each adhesive system are listed in table 3. No differences were found between adhesive systems submitted to the same LASER type. On the other hand, differences were found for LASER factor, without interaction between the variables. The use of Nd:YAG LASER resulted in higher Δt than Diode LASER for all adhesives systems.

DISCUSSION

Thermal injuries to the pulp have always been studied by extensive research since excessive heat might lead to pulpal necrosis. Classical studies [18] demonstrated that temperature variation (Δt) greater than 5.5 °C has a high potential for pulp damage, while more recent studies suggest that tolerable Δt is 11.2 °C[19]. The present study evaluated the

Table 3 - Mean ± standard deviation of variation in intra pulp chamber temperature (°C).

n = 5	MP	SB	CSE	EO
Nd:YAG	12.60 (±2.51) Ba	10.40 (±5.03) Ba	11.80 (±5.12) Ba	10.20 (±2.39) Ba
Diodo	4.4 (±1.82) Aa	5.20 (±1.54) Aa	4.60 (±1.14) Aa	3.60 (±1.52) Aa

**Different capital letters indicate differences between rows of the same column (p > 0.05).*
***Different lowercase letters indicate differences between the columns of the same row (p > 005).*

variations in intra pulp chamber (Δt) determined by irradiation of different adhesive systems with Nd:YAG or Diode LASERs on dentin.

According to the results, no differences were observed in Δt obtained between the adhesive systems. Some authors [20] observed differences in Δt when different dyes were applied to dentin surface, which may absorb the energy in the spectrum of LASER irradiation (1064 nm and 970 nm) and determine increased temperatures. The results of the present study suggests, based on the absence of significant differences between the adhesive systems, that besides the different chemical composition, all presented similar interaction with tested LASERs. A a near infrared spectroscopy of the adhesive systems is however necessary to confirm this hypothesis.

When LASER factor was analyzed, it was observed that Nd:YAG LASER caused an increased Δt when compared to Diode LASER, rejecting the second null hypothesis. Once the same parameters were used for both groups, the difference in Δt can be attributed to the wavelength, which is inherent to the type of LASER and can determine greater or lesser energy absorption by the substrate, generating different patterns of heating.

Gutknecht et al. [21] noted that water has a higher absorption coefficient to Nd:YAG LASER when compared to Diode LASER, which may have determined the higher heating observed for Nd:YAG LASER. Other authors [22] claim that Diode LASER depth of action is lower than Nd:YAG LASER, [14] which can also contribute to Δt lower values observed. Also some authors do not recommend the use of Nd:YAG LASER on continuous mode within dental substrate, because higher temperature might lead to protein denaturation [23].

The low temperature obtained with Diode Laser is in accordance to classic studies of Zach and Cohen. Despite higher values of Δt determined by Nd:YAG LASER, the average Δt can be considered tolerable, since more recent studies demonstrated clinicanly and histologically that increase of 11.2 °C does not cause problems [19]. There is no evidence that heating compromises adhesion due to increase in temperature; on the other hand, studies using similar parameters found increase in bond strength of different adhesive systems to dentin [17,15].

The present study has the objective of contributing to the possible clinical use of the technique. Complementary studies are still needed, since the oral environment and the presence of pulp may influence energy absorption. Studies evaluating the longevity of adhesion obtained by employing the technique, and better understanding of mechanism of lasers over adhesive systems should still be performed prior to clinical use. Standard parameters are still needed to ensure greater safety of LASERs.

CONCLUSION

Within the limitations of this study, it can be concluded that temperature variation is related to LASER type, reagardless the adhesive system used. Nd:YAG LASER might provide a higher potential to cause a pulp damage.

REFERENCES

1. Slot DE, Timmerman MF, Versteeg PA, Van der Velden U, Van der Weijden FA. Adjunctive clinical effect of a water-cooled Nd:YAG laser in a periodontal maintenance care programme: a randomized controlled trial. J Clin Periodontol. 2012 Dec; 39(12):1159-65.
2. Sgolastra F, Petrucci A, Severino M, Gatto R, Monaco A. Lasers for the treatment of dentin hypersensitivity: a meta-analysis. J Dent Res. 2013 Jun;92(6):492-9.
3. Bago I, Plečko V, Gabrić Pandurić D, Schauperl Z, Baraba A, Anić I. Antimicrobial efficacy of a high-power diode laser, photo-activated disinfection, conventional and sonic activated irrigation during root canal treatment. Int Endod J. 2013 Apr;46(4):339-47.
4. Sanz-Moliner JD, Nart J, Cohen RE, Ciancio SG. The Effect of an 810-nm diode laser on postoperative pain and tissue response after modified widman flap surgery: a pilot study in humans. J Periodontol. 2013 Feb;84(2):152-8.
5. Hibst R, Keller U. Experimental studies of the application of the Er:YAG laser on dental hard substances: I. Measurement of the ablation rate. Lasers Surg Med. 1989;9(4):338-44.

6. Keller U, Hibst R, Geurtsen W, Schilke R, Heidemann D, Klaiber B, et al. Erbium:YAG laser application in caries therapy. Evaluation of patient perception and acceptance. J Dent. 1998 Nov;26(8):649-56.

7. Delfino CS, Souza-Zaroni WC, Corona SAM, Palma-Dibb RG. Microtensile bond strength of composite resin to human enamel prepared using Erbium: Yttrium Aluminum Garnet laser. J Biomed Mater Res A. 2007 Feb;80(2):475-9.

8. Correa-Afonso AM, Ciconne-Nogueira JC, Pecora JD, Palma-Dibb RG. In vitro assessment of laser efficiency for caries prevention in pits and fissures. Microsc Res Tech. 2012 Feb;75(2):245-52.

9. Burkes EJ, Hoke J, Gomes E, Wolbarsht M. Wet versus dry enamel ablation by er-yag laser. J Prosthet Dent. 1992 Jun;67(6):847-51.

10. White JM, Fagan MC, Goodis HE. Intrapulpal temperatures during pulsed nd-yag laser treatment of dentin, in-vitro. J Periodontol. 1994 Mar;65(3):255-9.

11. Visuri SR, Walsh JT, Wigdor HA. Erbium laser ablation of dental hard tissue: Effect of water cooling. Lasers Surg Med. 1996;18(3):294-300.

12. Hubbezoglu I, Unal M, Zan R, Hurmuzlu F. Temperature rises during application of Er:YAG laser under different primary dentin thicknesses. Photomed Laser Surg. 2013 May;31(5):201-5.

13. Goncalves SED, de Araujo MAM, Demiao AJ. Dentin bond strength: Influence of laser irradiation, acid etching, and hypermineralization. J Clin Laser Med Surg. 1999 Apr;17(2):77-85.

14. Franke M, Taylor AW, Lago A, Fredel MC. Influence of Nd: YAG laser irradiation on an adhesive restorative procedure. Oper Dent. 2006 Sep-Oct;31(5):604-9.

15. Marimoto AK, Cunha LA, Yui KC, Huhtala MF, Barcellos DC, Prakki A, Gonçalves SE. Influence of Nd:YAG laser on the bond strength of self-etching and conventional adhesive systems to dental hard tissues. Oper Dent. 2013 Jul-Aug;38(4):447-55.

16. Araujo RM, Eduardo CP, Duarte Junior SL, Araujo MA, Loffredo LC. Microleakage and nanoleakage: influence of laser in cavity preparation and dentin pretreatment. J Clin Laser Med Surg. 2001Dec;19(6):325-32.

17. Maenosono RM, Bim Júnior O, Duarte MA, Palma-Dibb RG, Wang L, Ishikiriama SK. Diode laser irradiation increases microtensile bond strength of dentin. Braz Oral Res. 2015;29(1):1-5.

18. Zach L, Cohen G. Pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol. 1965 Apr;19:515-30.

19. Baldissara P, Catapano S, Scotti R. Clinical and histological evaluation of thermal injury thresholds in human teeth: A preliminary study. J Oral Rehabil. 1997 Nov;24(11):791-801.

20. Farhart PBA, Tanji EY; Farhart, RP; Zezell, D;M MIYAKAWA, Walter ; NOGUEIRA, Gessé e C. Model of thermal and optical effects in dental pulp during the neodymium and diode lasers irradiation. Braz Dent J. 2004;15:90.

21. Gutknecht N, Eduardo CP. A odontologia e o Laser- Atuação do Laser na Especialidade Odontológica. 1st ed. Sao Paulo: Quintessence, 2004. 320p.

22. Moritz A, Gutknecht N, Goharkhay K, Schoop U, Wernisch J, Sperr W. In vitro irradiation of infected root canals with a diode laser: Results of microbiologic, infrared spectrometric, and stain penetration examinations. Quintessence Int. 1997 Mar;28(3):205-9.

23. Launay Y, Mordon S, Cornil a, Brunetaud JM, Moschetto Y. Thermal effects of laser on dental tissues. Lasers Surg Med. 1987;7(6):473-7.

Prof. Dr. Sérgio Kiyoshi Ishikiriama
(Corresponding address)
Faculdade de Odontologia de Bauru - USP
Departamento de Dentística, Endodontia e Materiais Odontológicos
Alameda Dr. Otávio Pinheiro Brizola, 9-75 - Bauru - São Paulo - Brasil
Caixa Postal 73 - 17012-901 - Bauru - SP - Brasil
E-mail: serginho@usp.br

Date submitted: 2014 Dec 11
Accept submission: 2015 Mar 31