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.v18i4.1164

Effect of Nd:YAG laser in the bond strength of fiberglass posts

Efeito da aplicação de Laser Nd:YAG na adesão de pinos de fibra de vidro

Rayssa Ferreira ZANATTA[1], Beatriz Maria da FONSECA[1], Stella Renata ESTEVES[1], Carlos Rocha Gomes TORRES[1], Sergio Eduardo de Paiva GONÇALVES[1]

1 – Department of Restorative Dentistry – School of Dentistry – Institute of Science and Technology – UNESP – Univ Estadual Paulista – São José dos Campos – SP – Brazil.

ABSTRACT

Objective: The aim of the present study was to compare the effects of Nd:YAG laser application in root canals on bond strengths of fiber posts. **Material and Methods:** Thirty single-rooted bovines were randomly divided into three groups (n = 10); root canal instrumentation was performed, and pretreatment was conducted as follows: C group: conventional treatment (without laser irradiation); ALC group: Nd:YAG laser was applied after adhesive; and LAC group: Nd:YAG laser was applied before adhesive. The fiber posts Rebilda 15 DC (Voco) were cemented with an adhesive system and resin cement, in accordance with the manufacturer's instructions. Six slices with 1.0mm height was obtained for of each root and bond strength was measured by push-out test using a universal testing machine (0.5 mm/min). Data were analyzed using Kruskal-Wallis and Dunn's tests ($p < 0.05$). **Results:** Push-out bond strengths to root canal dentin were affected by the type of treatment and root third. The use of Nd:YAG laser after the application of adhesive system had a higher bonding performance compared with the use of laser before the application. However, both of them were similar to the control group. Also, cervical and medium third presented higher bond strength values than the apical third. **Conclusion:** It must be conclude, in the conditions in which the study was conduct, that the use of laser irradiation did not improve the bonding performance of resinous cement inside the root canal.

KEYWORDS

Laser Nd:YAG; Fiberglass pins; Adhesive resistence; Adhesion.

RESUMO

Objective: O objetivo deste estudo foi comparar o efeito da aplicação intrarradicular do laser Nd:YAG na adesão de pinos de fibra de vidro. **Material e Métodos:** Trinta raízes unirradiculares de incisivos bovinos foram selecionadas, e após instrumentação, foram divididas aleatoriamente em três grupos (n = 10) de acordo com o tratamento das paredes do canal: C: tratamento convencional (sem radiação laser), ALC: aplicação do Laser Nd:YAG após o adesivo; e LAC: aplicação do laser antes do adesivo. Pinos de fibra de vidro Rebilda 15 DC (Voco) foram cimentados com adesivo e cimento resinoso de acordo com instruções do fabricante. Seis fatias (duas para cada terço radicular) com 1 mm de espessura foram obtidas de cada raiz para mensuração da resistência adesiva por meio de teste push-out realizado em máquina de ensaio universal (0,5 mm/min). Os dados foram analisados por meio dos testes Kruskal-Wallis e Dunn ($p < 0,05$). **Resultados:** A resistência adesiva dos pinos na dentina radicular foi influenciada pelo tipo de tratamento e terço radicular. O uso do laser de Nd:YAG após a aplicação do adesivo apresentou melhor performance comparada ao seu uso antes do adesivo, porém, ambos foram similares ao controle. Ainda, os terços cervical e médio apresentaram maior resistência comparado ao apical. **Conclusão:** Conclui-se que, o uso da irradiação laser nos parâmetros estudados, não melhora a performance adesiva de cimentos resinosos dentro do canal radicular.

PALAVRAS-CHAVE

Laser Nd:YAG; Pinos de fibra de vidro; Resistencia adesiva; Adesão.

INTRODUCTION

The longitudinal success of restorative rehabilitations of endodontically treated teeth depend upon the result of the bonding quality between fibers reinforced posts and composite cores and / or luting agents [1].

Usually the rehabilitation of endodontically treated teeth with great structural loss requires the use of posts for core retention. The use of fiber-reinforced posts have become popular mainly because their mechanical advantages, such as elastic modulus similar to dentin, thus reducing the risk of root fractures [2]. Besides that, the translucent fiberglass option also allows a better light transmission inside the root canal, compared with opaque posts, improving resinous cement polymerization [3], and presents superior esthetic [4].

Although adhesive luting is recommended for rehabilitation with fiberglass posts, and the formation of a hybrid layer as well as resin tags to the root canal dentin had been shown [5], debonding is the most common failure of these restorations [2,6], due to the high C-factor [7]. In order to improve bonding of fiberglass posts, many studies have investigated the effect of pretreatments in their surface [8-11], however the pretreatment of root dentin still remains uncertain.

Lasers have being used inside the root for a while in endodontics aiming to reduce the microbial level, and also as a supporting treatment for conventional endodontic treatment [12]. Likewise, some studies have found that the use of lasers, such as Nd:YAG, improves the bonding of endodontic sealers to dentin, due better removal of the smear layer [13-15]. Moreover, literature shows that the irradiation of laser in coronal dentin over uncured adhesive seals its tubules and forms fungiform projections that improves mechanical adhesion and promote a interchange between adhesive and the modified hybrid layer by laser, improving chemical adhesion [16,17].

Therefore, the aim of the current study was to evaluate the effect of Nd:YAG laser on the bond strength between the fiberglass post and laser-treated root canal before and after adhesive photo-curing. The null hypotheses tested are: the use of laser does not influence the bond strength of the resin cement; there is no difference in bond strength for the different root thirds.

METHODS

Specimen Preparation

Thirty freshly extracted bovine incisors with similar dimensions were selected for the study. Each tooth had its crown removed with help of a low speed diamond blade (Microdont, São Paulo, SP, Brazil) under water irrigation, with a perpendicular cut below cement-enamel junction. The reminiscent roots were standardized with 15 mm.

Pulp tissue was removed from roots by endodontic k-file #10 (Maillefer, Petropólis, Rio de Janeiro, Brazil), and enlarged with Gates Glidden Burs (Maillefer n.2 – 15 mm, n.3 – 10 mm and n.4 - 5 mm). After that, roots were mechanically prepared with Rebilda Post 15 bur (Voco GmbH, Cuxhaven, Germany), specific from the post system, in 10 mm length. Roots were randomly divided into three groups (n=10) according with the technique used to cement the post: C group, in which the posts were lutted following manufacturer instructions, as a control group; ALC group, in which Nd:YAG laser was applied on the root after adhesive application; and, LAC, in which Nd:YAG laser was applied on the root before adhesive application.

Post Cementation

Roots were rinsed with sodium hypochlorite 1.0% (Asfer, Industria Quimica LTDA – São Caetano do Sul, Sao Paulo, Brazil) for 60 s, to remove debris and smear layer, washed with saline solution 0.9% (NaCl) and dried with paper points (Meta, Injecta – São Bernardo do Campo, Sao Paulo, Brazil).

For the group C, after root preparation, the adhesive Futurabond U (Voco) was applied over the dentin walls with a microbrush, and after 20 s an oil-free air jet was applied for 5 s, to promote the solvent evaporation. Being a self-etching adhesive, no additional etching with phosphoric acid was required. The fiberglass posts were cleaned with 70% ethanol and a silane coupling agent was applied (Ceramic Bond – Voco). The root canal was filled with the dual-cure resin cement Rebilda DC (Voco), with help of a lentulo bur, and the fiberglass post Rebilda Post 15 (Voco) was placed inside it. After 3 min for chemical cure, the cement was lightcured with halogen light (600 mW/cm² - Elipar, 3M/ESPE; St Paul, Minnesota, USA) for 40 s parallel of post long axis.

For group ALC, the adhesive system was applied the same way described for group C, and before post cementation, the Nd:YAG laser (Pulse Master 600 IQ, American Dental Technologies, Inc. Corpus Christi, TX, USA) was used. The laser irradiation was set in 60mJ of energy, with frequency of 10 Hz, wave length of 1.064 μm, and energy density of 47.7 J/cm². An optical fiber tip with 400 μm in diameter was adjusted on the laser handset to deliver the irradiation by contact, introducing the optical fiber in the total length of the root canal and moving to cervical region by helicoidal movements during 30 s. After the laser irradiation, the canal was filled with the resin cement and the fiberglass post inserted in the same way described for group C.

For group LAC, after root and post preparation, the Nd:YAG laser was firstly applied on the root canals, with the same parameters set for group ALC, and then, the fiberglass post cementation proceeded the same way described in group C.

Push-out test

For the push-out test each root was sectioned perpendicular to its long axis into six slices of 1 mm thickness each (being two slices for each root third), using a low speed diamond saw under water cooling (Labcut 1010, EXTEC, Sao Paulo, Brazil). The thickness of each slice was measured using a digital caliper (Mitutoyo, Japan) to confirm accuracy, and the value was recorded.

To calculate the exact bonding surface, the tapered design of the posts was considered. Each specimen was measured with stereomicroscope, and the bonding surface was calculated using the formula of a conical frustum:

$$\textbf{Bonding Area} = \pi(R_1 + R_2)\sqrt{}R_1 - R_2)^2 + h^2,$$

where π is the constant 3.14; R1 is the larger radius; R2, the lower radius; and h, the thickness of the dental slice.

The slice was centered over the hole of the base and a compressive load was applied at a speed of 0.5 mm/min with a punch in a universal testing machine (EMIC DL1000, Curitiba, Paraná, Brazil) until failure, with a 20 Kgf load cell. The force required to cause failure was recorded by the software (TESC; EMIC) and the push-out bond strength was expressed in MPa by dividing the load (N) at failure by the bonded area of the post segment (mm²). A special care was took with the punch and the base, so that the punch was always smaller than the post diameter and the center hole at the base was always larger than the cement/dentin interface.

Statistical Analysis

The bond strength data were examined for normality of distribution and homogeneity. As data failed for normal distribution, a non-parametric analysis of variance (Kruskal-Wallis) test were performed for cementation technique and root third, followed by Dunn's test ($p < 0.05$).

RESULTS

The mean of bond strength (MPa) and standard deviation (SD) are listened in Table 1. The statistical revealed significant differences for root treatment ($p = 0.01$) and for root third (p = 0.01). Dunn's test showed no difference between the control group and the groups treated with laser, but LAC samples had higher bond strength than ALC ones. Related to root third, the apical specimens had lower bond strength than medium and cervical ones.

Table 1 - Mean and Standard Deviation of bond strength (MPa) from groups tested

	Root Treatment		
Root Third	**Control**	**ALC**	**LAC**
Cervical	10.68 (7.24) ABa	6.67 (3.26) Aa	11.70 (5.14) Ba
Medium	9.19 (3.70) ABa	9.13 (4,54) Aa	9.78 (4.11) Ba
Apical	6.27 (2.41) ABb	4.35 (2,71) Ab	7.04 (2.26) Bb

Uppercase letters shows difference between columns and lowercase letters shows difference between lines.

DISCUSSION

The first null hypothesis tested was accepted as that the use of laser did not influence in the bond strength of the resin cement used, but the second was denied, as the apical third presented lower values than the cervical and middles ones.

Previous studies show that when Nd laser is applied previously to the adhesive system, it results in reduction of bond strength and in increase of acid resistance when compared to cavities non-irradiated by the laser, due to tubules obliteration and difficulties in etching the melted dentin. [16,18,19]. This observation leads Gonçalves et. al. [16], to irradiate dentin after application of the adhesive system and previously its cure, resulting in the increase of bond strength and recrystallization of dentin. Many studies have been conducted using this methodology, presenting favorable results regarding bond strength, marginal sealing, and hybrid layer thickness [17,18,20-22]. In this study we observed that both laser techniques presented similar values to the control group, having no positive effect over bond strength of fiberglass posts in root canal. That might have happened due to the difficult to irradiate the laser inside the canal; once the lack of a standard application method might have promoted areas more irradiated than others. We can consider this fact a limitation of this study. Also previous studies shows that when Nd:YAG laser is used associated with irrigant solution to clean the root canal before post cementation, it promotes tubule occlusion without interfering in the bond strength [23,24], corroborating with the results found in this study.

The parameters used by Gonçalves et al. were totally different due to the characteristics of the Nd:YLF laser in lab conditions (2500 W of power and 0.3 Hz of frequency). It was proposed the same energy parameter used by Matos et al. [18] believing that higher energy levels would induce cracks and grains in dentin, making it more porous and permeable [25]. Besides that, it has being shown that the use of Nd:YAG laser in energies higher than 60 mJ induces the increase of local temperature up to 50 ºC in enamel [26], so it can be assumed that in root dentin the increase of energy might also promote undesirable temperature changes and could cause alterations in the periodontal ligament [27].

Regarding the bonding performance in the root thirds, translucent fiberglass posts have been introduced to dentistry in order to improve the light transmission inside the root canal [28]. However it has been shown that the light is mostly transmitted in the cervical and middle thirds, and does not reach the apical third in order to cure the resin cement properly [29]. The type of cement used is also critical for the success of fiberglass post cementation, with better results found for dual cure resin cement compared with chemical cure cements [30]. Despite being a dual-cured material, deeper portions of cement are inaccessible to light, rendering the material dependent on the chemical curing. This can reduce the degree of conversion of the cement and can consequently affect its mechanical properties [31]. The findings of this study showed lower bond strength in the apical root third compared with cervical and middle ones for all groups tested. The incomplete resin cement cure, summed with the high C-factor found inside the root canal and the lower amount off dentin tubules, are usually responsible for the worse bonding performance in the apical third [28,32,33].

Despite all the advantages of the fiberglass post, the adhesive bonding between the post and radicular dentin is still a not solved problem. Failures usually occur in the adhesive junction, by the absence of a strong and stable chemical binding [34-37]. Therefore, treatments of the dentin surface should be more investigate to minimize flaws during cementation and increase bond strength.

CONCLUSION

It must be conclude in the conditions in which this study was conduct that the use of laser irradiation did not improve the bonding performance of resinous cement inside the root canal. The use of 60 mJ of laser energy is not sufficient to increase the bond strength, been similar to results without laser. Related to the root thirds, cervical and middle ones had better bond strength than the apical for all groups tested.

REFERENCES

1. Arslan H, Barutcigil C, Yilmaz CB, Ceyhanli KT, Topcuoglu HS. Push-out bond strength between composite core buildup and fiber-reinforced posts after different surface treatments. Photomed Laser Surg. 2013 Jul;31(7):328-33
2. Santos AF, Meira JB, Tanaka CB, Xavier TA, Ballester RY, Lima RG, et al. Can fiber posts increase root stresses and reduce fracture? J Dent Res. 2010 Jun;89(6):587-91.
3. Balbosh A, Kern M. Effect of surface treatment on retention of glass-fiber endodontic posts. J Prosthet Dent. 2006 Mar;95(3):218-23.
4. Peutzfeldt A, Asmussen E. Determinants of in vitro gap formation of resin composites. J Dent. 2004 Feb;32(2):109-15.
5. Bitter K, Paris S, Martus P, Schartner R, Kielbassa AM. A Confocal Laser Scanning Microscope investigation of different dental adhesives bonded to root canal dentine. Int Endod J. 2004 Dec;37(12):840-8.
6. Ferrari M, Cagidiaco MC, Goracci C, Vichi A, Mason PN, Radovic I, et al. Long-term retrospective study of the clinical performance of fiber posts. Am J Dent. 2007 Oct;20(5):287-91.
7. Tay FR, Loushine RJ, Lambrechts P, Weller RN, Pashley DH. Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod. 2005 Aug;31(8):584-9.
8. Arcoria CJ, Lippas MG, Vitasek BA. Enamel surface roughness analysis after laser ablation and acid-etching. J Oral Rehabil. 1993 Mar;20(2):213-24.
9. Murray AK, Attrill DC, Dickinson MR. The effects of XeCl laser etching of Ni-Cr alloy on bond strengths to composite resin: a comparison with sandblasting procedures. Dent Mater. 2005 Jun;21(6):538-44.
10. Tuncdemir AR, Yildirim C, Guller F, Ozcan E, Usumez A. The effect of post surface treatments on the bond strength of fiber posts to root surfaces. Lasers Med Sci. 2013 Jan;28(1):13-8.
11. Vano M, Goracci C, Monticelli F, Tognini F, Gabriele M, Tay FR, et al. The adhesion between fibre posts and composite resin cores: the evaluation of microtensile bond strength following various surface chemical treatments to posts. Int Endod J. 2006 Jan;39(1):31-9.
12. Meire MA, Coenye T, Nelis HJ, De Moor RJ. Evaluation of Nd:YAG and Er:YAG irradiation, antibacterial photodynamic therapy and sodium hypochlorite treatment on Enterococcus faecalis biofilms. Int Endod J. 2012 May;45(5):482-91.
13. Wen X, Liu L, Nie X, Zhang L, Deng M, Chen Y. Effect of pulse Nd:YAG laser on bond strength and microleakage of resin to human dentine. Photomed Laser Surg. 2010 Dec;28(6):741-6.
14. Das M, Kumar GA, Ramesh S, Garapati S, Sharma D. An in vitro evaluation of microtensile bond strength of resin-based sealer with dentin treated with diode and Nd:YAG laser. J Contemp Dent Pract. 2013 Mar 1;14(2):183-7.
15. Ayranci LB, Koseoglu M. The evalution of the effects of different irrigating solutions and laser systems on adhesion of resin-based root canal sealers. Photomed Laser Surg. 2014 Mar;32(3):152-9.
16. Goncalves SE, de Araujo MA, Damiao AJ. Dentin bond strength: influence of laser irradiation, acid etching, and hypermineralization. J Clin Laser Med Surg. 1999 Apr;17(2):77-85.
17. Kamozaki M, Prakki A, Perote L, Gutierrez N, Pagani C. The effect of CCP-ACP and Nd:YAG laser on the bond strength of softened dentin. Braz Oral Res. 2015;29. pii: S1806-83242015000100268.
18. Matos AB, Oliveira DC, Navarro RS, de Eduardo CP, Matson E. Nd:YAG laser influence on tensile bond strength of self-etching adhesive systems. J Clin Laser Med Surg. 2000 Oct;18(5):253-7.
19. Ghiggi PC, Dall Agnol RJ, Burnett LH, Borges GA, Spohr AM. Effect of the Nd:YAG and the Er:YAG laser on the adhesive-dentin interface: a scanning electron microscopy study. Photomed Laser Surg. 2010 Apr;28(2):195-200.
20. Arisu HD, Dalkihç E, Üçtaşli MB. Effect of desensitizing agents on the microtensile bond strength of a two-step self-etch adhesive to dentin. Oper Dent. 2011 Mar-Apr;36(2):153-61.
21. 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.
22. Marimoto AK, Cunha LA, Yui KC, Huhtala MF, Barcellos DC, Prakki A, et al. 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.
23. Martinho C, Carvalho C, Oliveira L, Lacerda A, Xavier A, Gullo M, et al. Comparison of different dentin pretreatment protocols on the bond strength of glass fiber post using self-etching adhesive. J Endod. 2015 Jan;41(1):83-7.

24. Pucci C, Lacerda A, Gullo M, Xavier A, Torres C, Carvalho C. Evaluation of the influence of the Nd:YAG laser and different irrigants on the bond strength of the adhesion of the fiber posts. World J Dent. 2013;4(3):170-4.

25. Cox C, Pearson G, Palmer G. Preliminary in vitro investigations of the effects of pulsed Nd:YAG laser irradiation on enamel and dentin. Biomaterials. 1994 Nov;15(14):1145-51.

26. Valério R, da Cunha V, Galo R, de Lima F, Bachmann L, Corona S, et al. Influence of the Nd:YAG laser pulse duration on the temperature of primary enamel. Scientific World Journal. 2015;2015:396962. doi: 10.1155/2015/396962. Epub 2015 Mar 22.

27. Amade ES, Novais VR, Roscoe MG, Azevedo FM, Bicalho AA, Soares CJ. Root dentin strain and temperature rise during endodontic treatment and post rehabilitation. Braz Dent J. 2013 Nov-Dec;24(6):591-8.

28. dos Santos Alves Morgan LF, Peixoto RT, de Castro Albuquerque R, Santos Correa MF, de Abreu Poletto LT, Pinotti MB. Light transmission through a translucent fiber post. J Endod. 2008 Mar;34(3):299-302.

29. Radovic I, Corciolani G, Magni E, Krstanovic G, Pavlovic V, Vulicevic ZR, et al. Light transmission through fiber post: the effect on adhesion, elastic modulus and hardness of dual-cure resin cement. Dent Mater. 2009 Jul;25(7):837-44.

30. Farina AP, Cecchin D, Garcia Lda F, Naves LZ, Pires-de-Souza Fde C. Bond strength of fibre glass and carbon fibre posts to the root canal walls using different resin cements. Aust Endod J. 2011 Aug;37(2):44-50.

31. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod. 2010 Sep;36(9):1543-6.

32. Faria e Silva AL, Arias VG, Soares LE, Martin AA, Martins LR. Influence of fiber-post translucency on the degree of conversion of a dual-cured resin cement. J Endod. 2007 Mar;33(3):303-5.

33. D'Arcangelo C, Zazzeroni S, D'Amario M, Vadini M, De Angelis F, Trubiani O, et al. Bond strengths of three types of fibre-reinforced post systems in various regions of root canals. Int Endod J. 2008 Apr;41(4):322-8.

34. Choi Y, Pae A, Park EJ, Wright RF. The effect of surface treatment of fiber-reinforced posts on adhesion of a resin-based luting agent. J Prosthet Dent. 2010 Jun;103(6):362-8.

35. Yenisey M, Kulunk S. Effects of chemical surface treatments of quartz and glass fiber posts on the retention of a composite resin. J Prosthet Dent. 2008 Jan;99(1):38-45.

36. Albashaireh ZS, Ghazal M, Kern M. Effects of endodontic post surface treatment, dentin conditioning, and artificial aging on the retention of glass fiber-reinforced composite resin posts. J Prosthet Dent. 2010 Jan;103(1):31-9.

37. Zhong B, Zhang Y, Zhou J, Chen L, Li D, Tan J. UV irradiation improves the bond strength of resin cement to fiber posts. Dent Mater J. 2011;30(4):455-60.

Sergio Eduardo de Paiva Gonçalves
(Corresponding address)
Department of Restorative Dentistry, Institute of Science and Tecnology
Avenida Engenheiro Francisco José Longo, 777, Jardim São Dimas,
São José dos Campos, SP,
CEP: 12245-000, Brazil,
email: sergio@fosjc.unesp.br

Date submitted: 2015 Aug 15
Accept submission: 2015 Nov 10