Materials Research. 2012; 15(4): 491-494
DOI: 10.1590/S1516-14392012005000060

Influence of Er,Cr:YSGG Laser on Bond Strength of Self-Adhesive Resin Cement

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Received: August 6, 2011; Revised: February 26, 2012

The purpose of this study was to investigate the bond strength of fiber post previously laser treated root canals. Forty single-rooted bovine teeth were endodontically treated, randomly and equally divided into two main groups according to the type of pretreatment: G1: 2.5% NaOCl (control group); and G2: Er,Cr:YSGG laser. Each group was further subdivided into 2 groups based on the category of adhesive systems/luting materials used: a: an etch-and-rinse resin cement (Single Bond/RelyX ARC; 3M ESPE), and b: a self-adhesive resin cement (Rely X Unicem; 3M ESPE). Three 1.5 mm thick slabs were obtained per root and the push-out test was performed at a crosshead speed of 0.5 mm/min until post dislodgement occurred. Data were analyzed by ANOVA and post-hoc Tukey's test at a pre-set alpha of 0.05. Analysis of variance showed no statistically significant difference ($p > 0.05$) among the groups G1a (25.44 ± 2.35) and G1b (23.62 ± 3.48), G2a (11.77 ± 2.67) and G2b (9.93 ± 3.37). Fractures were observed at the interface between the dentin and the resin in all groups. The Er,Cr:YSGG laser irradiation did not influence on the bond strength of the resin cements and the etch-and-rinse resin cement had better results on bond strength than self-adhesive resin cement.

Keywords: *Er,Cr:YSGG laser, root canal dentin, push-out bond strength, fiber post, resin cement*

1. Introduction

Successful endodontic treatment consists on cleaning, shaping, disinfecting and sealing the root canal. Cleaning occurs simultaneously with biomechanical preparation, elimination of bacteria, their sub-products, degenerated pulp tissue and contaminated dentin creating a surgical space that permits proper sealing[1].

However, conventional root canal preparation and rinsing solutions cannot always eliminate the remaining bacteria in the root canal[2]. A complementary method for the disinfection of root canals is the use of high-intensity lasers.

The Er,Cr:YSGG laser is generally used for removing organic and inorganic tissues along the root canal and reducing bacterial contamination significantly[3]. It provides a wavelength that coincides with the maximum absorption wavelength of water and hydroxyapatite and the surrounding tissues are minimally affected[3].

The use of laser for reducing bacterial contamination along the root canal modifies the dentine surface of the root canal[3]. The dentin surface is an important aspect for cementation of intraradicular posts.

Self-adhesive luting materials were introduced recently to reduce the number of cementation steps by eliminating the pre-treatment of the tooth[4-7]. Their adhesion originates by acidic monomers that simultaneously demineralize and infiltrate the tooth substrate, resulting in micromechanical retention[8-11]. In additional, secondary reactions provide additional chemical bonding to the dentin surface[6,3].

The modification of dentin surface influence directly the bond strength of the luting cements in the root canal and there is no study about the influence of high-intensity lasers on bond strength of self-adhesive luting materials. The purpose of this study was to verify the retention of fiber post luted with self-adhesive resin cement.

2. Material and Methods

2.1. *Specimen preparation*

The crowns of bovine teeth were removed at the cement-enamel junction using a low-speed diamond disc (Isomet III; Buehler, Lake Bluff, IL) under constant water-cooling.

The root canals were prepared until 1 mm from the apex using rotary nickel titanium instruments (Mity, Loser, Leverkusen, Germany) according to the crown-down technique. The master apical file was 40.06 and the irrigation solution between instrumentation was 2.5% NaOCl. Prepared root segments were obturated with gutta-percha

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and an epoxy resin-based canal sealer (AH Plus®, Dentsply DeTrey, Konstanz). The specimens were then stored at 37 °C and 100% relative humidity for a period of 24 hours.

2.2. *Post preparation*

The post space of each specimen was enlarged with a nº. 2 drill from the Exacto post system (Angelus, PR, Brazil) to a length of 10 mm, leaving 4 mm of gutta-percha remaining in the apical third. To standardize the method, the same operator performed all the procedures.

2.3. *Pre-treatment of root canal walls*

Forty single-rooted bovine teeth were randomly and equally divided into two main groups according to the type of pretreatment:

G1: 2.5% NaOCl (control group) – The irrigation occurred during 60 seconds;

G2: Er,Cr:YSGG laser – The laser equipment used was a Waterlase Millenium system (Biolase Technologies, San Clemente, CA), which emits photons at a wavelength of 2,78 µm. The output power was 0.75 W and water/air flow of 24 and 34%, respectively. The focal area of the tip was 320 µm.

2.4. *Post cementation*

Each group was further subdivided into 2 groups based on the category of adhesive systems/luting materials used:

A: Etch-and-rinse resin cement (Single Bond/RelyX ARC; 3M ESPE, St Louis, USA) – Intracanal dentin was etched with 37% phosphoric acid for 15 seconds, rinsed with distilled water for 15 seconds, and then gently dried with absorbent paper points. After etching the dentin, the cement was inserted into the root canal and the fiber post was inserted and excess cement was removed;

B: Self-adhesive resin cement (Rely X Unicem; 3M ESPE3M ESPE, St Louis, USA) – The cement was inserted into the root canal and the fiber post was inserted and excess cement was removed.

All specimens were light activation for 30 seconds at the buccal and lingual surfaces, for a total of 60 seconds of light exposure, with 5 mm of distance between source and root.

2.5. *Push-out bond testing*

Three 1.5 mm thick slabs from cervical root region were obtained per specimen and were positioned on a base, with a central hole, in a universal testing machine (DL2000, EMIC, São José dos Pinhais, PR, Brazil). The push-out test was performed by applying a compressive load by using a cylindrical plunger attached to the upper portion of the testing machine. A crosshead speed of 0.5 mm/min was applied until post dislodgement occurred.

The peak force, at the point of post segment extrusion from the test specimen, was used as the point of bond failure and recorded in Newton (N). Then, push-out bond strength values in MPa were calculated dividing this force by the bonded area of the post segment. This refers to the lateral surface of a post, which is calculated using the following equation:

$$S = 2\varpi r \times h \quad (1)$$

where ϖ is the constant 3.14, r is the post radius and h is the slice thickness in mm.

2.6. *Statistical analysis*

The data obtained was submitted to normality test (Shapiro Wilk). Normal data was found; therefore two-way ANOVA test was used to compare variables (pre-treatment and adhesive systems/luting materials). Post-hoc tests were conducted using a Tukey's multiple comparison test at $p < 0.05$.

3. Results

The results of the bond strength analysis were submitted to normality test in order to verify their normal distribution (Table 1). Considering that the obtained data were parametric, the analysis were performed by using the 2-way analysis of variance (ANOVA) (Table 2) and a post hoc test using the Tukey multiple comparison test at $\alpha = 0.05$ (Table 3). The mean (MPa) and standard deviation for all groups are in Table 4. All failures occurred at the dentin/resin interface.

Table 1. Normality test applied for all groups.

Groups	W	p value	Alpha = 0.05
G1a	0.9596	0.3027	ns
G1b	0.9565	0.2516	ns
G2b	0.9424	0.1057	ns
G2b	0.9542	0.2182	ns

ns = No difference significant.

Table 2. ANOVA 2-way analysis of variance.

	SS	df	MS
Treatment (between columns)	5709	3	1903
Treatment (between rows)	326.1	29	11.25
Residual (random)	725.0	87	8.334
Total	6760	119	

Table 3. Tukey multiple comparison test at $\alpha = 0.05$.

	Mean diff.	q	Summary	95% Cl of diff.
G1a × G1b	13.67	25.94	***	11.71 to 15.63
G1a × G2a	1.820	3.453	ns	–0.1373 to 3.777
G1a × G2b	15.50	29.40	***	13.54 to 17.45
G1b × G2a	–11.85	22.48	***	–13.81 to 9.893
G1b × G2b	1.827	3.467	ns	–0.1300 to 3.785
G2a × G2b	13.68	25.95	***	11.72 to 15.63

***Difference significant; ns = no difference significant.

Table 4. The push-out bond strength of all groups.

	Mean	SD
G1a	25.44[a]	2.35
G1b	11.77[b]	2.67
G2a	23.62[b]	3.48
G2b	9.93[a]	3.37

*Means followed by the same letters do not differ significantly ($\alpha = 0.05$).

4. Discussion

The Er,Cr:YSGG laser has been used widely in endodontic therapy due to their microbial reduction potential[12-16,3,17]. This laser has capacity of ablate enamel and dentin by the high absorption in water and also strong absorption by the hydroxyl radicals present in the hydroxyapatite structure[12,18]. Furthermore, it can create precise hard tissue cuts through the interaction of laser energy with atomized water droplets on the tissue interface resulting in the ablation of the tissue[19,16,17].

Most of smear layer and debris on root canal walls is removed by Er,Cr:YSGG laser, and dentinal tubules were patent[18,13]. The smear layer is composed of cut tooth structure and some nonspecific inorganic contaminants[13,11]. Different irrigant solutions have been used in order to remove smear layer partially, such as NaOCl and EDTA[20-22]. The NaOCl is an irrigant solution used widely in root canal treatment due to its bactericidal properties and ability to dissolve organic tissues[20,21].

Görgüi et al.[23] investigated the adaptation of a packable composite resin to lased root canal dentine when it was used as post material. The authors have found poor adaptation to root canal dentin when laser was applied at canal wall and more microleakage was detected. The alteration of dentine surface morphology at the root canal is an important aspect that influences the quality of adhesion between the filling material and root canal wall. Resin cements can be classified according to their mechanism of interaction with the smear layer. These cements can require application of an etch-and-rinse adhesive system or a self-etching primer. More recently, new resin cement was introduced which does not require any pre-treatment of dentin surface. Their clinical success is based on their ability to adequately bond to different restorative substrates and on their reduced technique and operator sensitivity[24,25]. For resin cement that requires an etch-and-rinse adhesive system (i.e. Relyx ARC), the application of 37% phosphoric acid promotes the removal of the smear layer and its adhesion is caused by the resin tags formation in depth. It explains our results, which showed that RelyX ARC did not affect by the laser application.

According to literature[26-28], the self-adhesive resin cement showed lower values of bond strength than etch-and-rinse adhesives used to resin cement. The self-adhesive resin cement is based on methacrylated phosphoric acid esters with several cement reactions during setting[29,30,9]. The acidic groups bind with calcium in the hydroxyapatite to form a stabilizing attachment between the methacrylate network and the tooth[4,5]. However, there is very limited interaction with enamel or dentin in terms of either smear layer demineralization or tag formation. Despite the partial removal of the smear layer, our results show that this cement had no significant difference after laser application.

Other studies[31,32] showed that the resin cements do not differ on bond strength values with pre-treatment of laser irradiations. However, Ramos et al.[33] showed the weakest adhesion for laser-ablated dentin surfaces when used Er:YAG laser irradiation (0.16 W 2 Hz/80 mJ). The authors explained that laser irradiation severely undermined the formation of consistent resin–dentin hybridization zones and yielded lower bond strengths. Capa et al.[32] reported that the effect of laser application depends on type of laser, energies density and tooth hard tissue (enamel and dentin).

5. Conclusion

The Er,Cr:YSGG laser irradiation did not influence on the bond strength of the resin cements and the etch-and-rinse resin cement had better results on bond strength than self-adhesive resin cement. The self-adhesive resin cement without pre-treatment of dentin promotes a very limited interaction in terms of either smear layer demineralization or tag formation, reducing the bond strength.

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