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Combined effect of fluoride varnish to Er:YAG or Nd:YAG laser on permeability of eroded root dentine

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ABSTRACT

Objective: This study evaluated the combined effect of fluoride varnish to Er:YAG or Nd:YAG laser on permeability of eroded root dentine.
Design: Sixty slabs of bovine root dentine ($2 \times 2 \times 2$ mm) were eroded with citric acid 0.3% (pH 3.2) during 2 h and then kept in artificial saliva during 24 h. Specimens were randomly assigned in 6 groups ($n = 10$), to receive the following treatments: fluoride varnish; fluoride varnish + Er:YAG laser; fluoride varnish + Nd:YAG laser; non-fluoride varnish; non-fluoride varnish + Er:YAG laser; non-fluoride varnish + Nd:YAG laser. The Er:YAG (100 mJ, 3 Hz) and Nd:YAG (70 mJ, 15 Hz) were applied for 10 s. Specimens were subjected to further erosive challenges with citric acid 0.3% 4×/day, during 1 min, for 5 days, remaining in artificial saliva between cycles. Dentin permeability was then assessed. Two-way ANOVA demonstrated no significant interaction between laser and varnish ($p = 0.858$).
Results: No effect was also detected for the main factor varnish ($p = 0.768$), while permeability of eroded root dentin was significantly lower when such substrate was laser-irradiated, no matter the laser source ($p < 0.001$).
Conclusions: This study concluded that Er:YAG and Nd:YAG lasers can be employed to control the permeability of eroded root dentin, regardless of fluoride varnish application.

1. Introduction

Dental erosion is defined as loss of dental structure by means of acid dissolution not involving bacteria (Addy & Shellis, 2006). These erosive acids can originate from intrinsic source (regurgitated gastric juice) (Addy & Shellis, 2006; Lussi, Jaeggi, & Zero, 2004; Scheutzel, 1996) or extrinsic source (dietary substances) (Addy & Shellis, 2006; Bahal & Djemal, 2014; Lussi et al., 2004). Dental erosion has been increasing and it is common and increases with age in both deciduous and adult dentitions (Kreulen et al., 2010; Van'T Spijker et al., 2009). Erosion starts by softening of the surface and is followed by continuous layer-by-layer dissolution leading to permanent loss of tooth volume with softened layer at the surface of the remaining tissue (West, Lussi, Seong, & Hellwig, 2013). When the dentin is exposed, the acids causing erosion can promote a surface with a large number of open and expanded tubules (Naylor, Aranha, Eduardo, Arana-Chavez, & Sobral, 2006), which is associated to dentin hypersensitivity (Addy, Absi, & Adams, 1987; Meurman, Drysdale, & Frank, 1991).

Due to the difficulty of controlling the etiological factors that contribute to dental erosion, some strategies have been developed to prevent or control dentin erosion. Among such approaches are the use of fluoride varnish (Magalhães, Levy, Rios, & Buzalaf, 2010; Magalhães, Levy, Rizzante, Rios, & Buzalaf, 2012), Nd:YAG laser (Naylor et al., 2006) and Er:YAG laser (He, Otsuki, Sadr, & Tagami, 2009).

The application of NaF varnish has been based on the evidence of its efficacy in reducing dentin erosion (Magalhães et al., 2010; Magalhães et al., 2012). While the NaF present in the formulation provides the formation of a CaF2-layer, which acts as a protective coating that has to be dissolved during an erosive episode before

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Table 1
Varnishes and composition.

Varnish	Composition	Manufacturer	Batch #
Fluoride varnish (Duraphat®)	Sodium fluoride 5%, fluoride in base of resin, alcohol 33,1%, natural resin, wax, saccharin and flavoring (pH 4,5)	Colgate-Palmolive, SP, Brazil	08.09-02
Nonfluoride varnish (Fórmula & Ação®)	Xylitol, hydrogenated resin, thickener, conservative, flavoring, deionized water and acrylic polymer	Fórmula & Ação, SP, Brazil	211828/1

the dentin beneath is affected (Ganss, Schlueter, & Klimek, 2007), the varnish mechanically protected dentin against erosion (Borges et al., 2012; Lan, Liu, & Lin, 1999).

With regards to laser irradiation, it has been observed that the dentin irradiated by Nd:YAG laser is fused and resolidified, obtaining an obliteration of the dentinal tubules (Al-Saud & Al-Nahedh, 2012; De Magalhães, Matson, De Rossi, & Alves, 2004; Lan & Liu, 1995; Liu, Lin, & Lan, 1997; Naylor et al., 2006; Zapletalová, Perina, Novotný, & ChmelÍcková, 2007). In fact, Nd:YAG irradiation has been associated to reduced dentin permeability (Aranha, Domingues, Franco, Gutknecht, & Eduardo, 2005), increased resistance to acids (Naylor et al., 2006; Schaller, Weihing, & Strub, 1997) and reduced dentin hypersensitivity (Birang, Poursamimi, Gutknecht, Lampert, & Mir, 2007; Dilsiz, Aydin, Canakci, & Gungormus, 2010; Kara & Orbak, 2009; Talesara, Kulloli, Shetty, & Kathariya, 2014; Yonaga, Kimura, & Matsumoto, 1999). Besides Nd:YAG laser, Er:YAG counterparts have been shown to produce a fused dentin surface (Aranha et al., 2005; Badran et al., 2011; Cakar et al., 2008; Dilsiz et al., 2010) and dentinal tubule occlusion (Badran et al., 2011; Cakar et al., 2008). This fusion in dentin surface has been associated with a lower permeability (Aranha et al., 2005). Other studies showed that after dentin irradiation with Er:YAG laser the acid resistance (He et al., 2009) and mineral content (Soares, Martin, Moriyama, Kurachi, & Martin, 2013) were increased and the dentinal hypersensitivity was decreased (Badran et al., 2011; Birang et al., 2007; Dilsiz et al., 2010; Ipci, Cakar, Kuru, & Yilmaz, 2009; Schwarz, Arweiler, Georg, & Reich, 2002).

Thereby, the aim of this study was to evaluate in vitro the combined effect of fluoride varnish with Er:YAG and Nd:YAG lasers on permeability of eroded root dentin whose characteristics resemble those found in hypersensitive dentin.

2. Material and methods

2.1. Experimental design

The factors studied were varnish treatment at two levels (fluoride and non-fluoride varnish) and laser irradiation at three levels (Er:YAG, Nd:YAG and unlased as control). The response variable was dentin permeability, measured as the percentage of copper ions that penetrated through the dentin.

2.2. Dentin sample preparation

Bovine incisors, freshly extracted and stored in a 0.1% thymol solution at 4 °C, were cleaned with curettes and water/pumice slurry with dental prophylactic cups. Sixty samples ($2 \times 2 \times 2$ mm) were prepared from the root dentin ($n = 10$). Two slabs were sectioned from each root using a sectioning machine (Isomet 1000, Buehler, Lake Bluff, IL, USA) with diamond disk (Isomet 1000; Buehler, Lake Bluff, IL, USA).

The root dentin slabs were coated with an acid-resistant nail varnish (Colorama, São Paulo, SP, Brazil) in two layers, except on the buccal surface.

2.3. Initial erosive lesion

The slabs were individually immersed in 20 mL of a 0.3% citric acid solution (pH 3.2) (Vanuspong, Eisenburger, & Addy, 2002; West, Hughes, & Addy, 2000) and placed in an orbital shaker (CT155, Cientec, Piracicaba, SP, Brazil), with a stirring velocity of 100 rpm for 2 h (West et al., 2000) to form erosive lesions, which resemble the condition of a hypersensitive dentin (Vanuspong et al., 2002). Afterwards, specimens were rinsed for 10 s with deionized water and stored in 10 mL of artificial saliva at 37 °C during 24 h.

The artificial saliva was similar to that described by Mcknight-Hanes and Whitford (1992) and modified by Amaechi, Higham, & Edgar (1999). It was composed of methyl-p-hydroxybenzoate; sodium carboxymethylcellulose; KCl; $MgCl_2.6H_2O$; $CaCl_2.2H_2O$; K_2HPO_4; and KH_2PO_4 in water solution.

2.4. Fluoride application and laser irradiation

After formation of erosive-like lesions, specimens were randomly assigned into two groups, according to the fluoride treatment to be employed: fluoride (Duraphat, São Paulo, SP, Brazil) or non-fluoride varnish (Fórmula & Ação, SP, São Paulo) (Table 1), and then subdivided into three groups to be irradiated with Er:YAG or Nd:YAG lasers or to be left unlased.

An approximate amount of 0.1 g (Attin et al., 1995) of the fluoride and non-fluoride varnishes was applied on eroded root dentin surface. One minute later, specimens were immersed in artificial saliva for 24 h, at 37 °C, and then the varnish layer was carefully removed with a scalpel blade #15.

The specimens were irradiated according to the parameters described in (Table 2). Er:YAG laser (Twin Light, Fidelis plus Fotona, Ljubljana, Eslovênia) irradiation was carried out by scanning the root dentin using an automatic custom designed apparatus (MCP, ElQuip, São Carlos, SP, Brazil), which kept the laser beam distant 17 mm from the specimen. The Nd:YAG (SmartFile (Deka, Calezando, Italy)), was used with a 300-mm diameter quartz fiber

Table 2
Er:YAG and Nd:YAG lasers parameters.

Parameters	Er:YAG laser	Nd:YAG laser
Wavelenght	2940 nm	1064 nm
Frequency	3 Hz	15 Hz
Energy	100 mJ	1 W
Refrigeration	1.5 mL/min	Without refrigeration
Time	10 s	10 s