The effect of laser-activated Acidulated Phosphate Fluoride on enamel submitted to erosive solution only: an in vitro preliminary evaluation

ABSTRACT

Aim The purpose of this in vitro study was to evaluate the potential effect of laser therapy on the prevention of erosive demineralisation either alone or combined with acidulated phosphate fluoride gel on human enamel. It was hypothesized that such a treatment would decrease enamel solubility.

Study Design Efficacy of 2940nm Er:YAG laser with preset parameters - alone or combined with APF (Acidulated Phosphate Fluoride) gel - was tested on freshly extracted human permanent molars.

Methods Ten sound human third molars were sectioned into 5 surfaces (2 x 3 mm) with hard tissue microtome and were randomly allocated into different treatment groups as follows. The Vicker’s hardness of each surface was obtained at the baseline. Group 1, negative control group: no treatment. Group 2, positive control group: only 1.23% APF gel (Denti-Care gel, Medicom) 1 minute application. Group 3: irradiated with “surface modification mode” (2940 nm, 1.2 J/cm², 10Hz, 300µm) Er:YAG laser. Group 4: Er:YAG laser application following 1.23% APF gel. Group 5: 1.23% APF gel following Er:YAG laser application. The demineralisation process was obtained by immersion of specimens in a soft drink for 10 minutes and then the Vickers hardness was reevaluated.

Statistics For statistical analyses within groups the Kruskal Wallis test was used, while for comparing groups the paired sample t test (significance p<0.05) was used.

Results The difference in microhardness values of each group obtained following the treatments was not statistically significant (p>0.05). Beside, no statistical difference was found in Vickers value related to the application of fluoride prior or after laser therapy.

Conclusion Er:YAG laser irradiation alone or combined with APF decreased the enamel solubility but combined treatment did not show any significant additional effect.

Keywords: Acidulated Phosphate Fluoride; Laser; Microhardness.

Introduction

Despite the significant decline in caries incidence in developed countries in the last few decades [Peterson and Lennon, 2004; Marthaler, 2004], there is an increasing number of other dental lesions causing tooth wear, such as erosion [Nunn, 1996; Serra et al., 2009]. The aetiology of erosion is multifactorial and not completely understood. Currently, the increased consumption of acidic foods and soft drinks is becoming an important factor for the development of the erosive condition [Magalhaes et al., 2009]. Despite the role of fluoride application on prevention of dental erosion is still debated, topical fluoride treatment is considered a good regimen to avoid demineralisation of dental hard tissues [Wiegand and Attin, 2003]. Topical fluoride applications result in deposition of CaF₂-like material on eroded dental surfaces, acting as a reservoir releasing fluoride during the demineralisation process. However the CaF₂-like material easily dissolves in most acidic drinks. Considering its temporary action, repeated applications of topical fluoride is needed to maintain its preventive effect [Ganss et al., 2007]. As erosive tooth wear cannot be completely prevented with the recommended strategies, further research is necessary to develop new measures with higher protective capabilities. Recently there is a growing awareness on the usefulness of lasers in modern dental practice, where they can be used as an adjunct or alternative to traditional approaches. Current literature support findings of increased fluoride uptake by lasers and alterations in chemical composition, or a combination of both [Tepper et al., 2004; Schmidlin et al., 2007]. However, there is no clear consensus about the exact mechanism but literature mostly focuses on thermal effect of lasers and alterations in chemical composition, or a combination of both [Tepper et al., 2004]. Due to the possibility of a synergistic effect between different treatments, it may be possible to increase their beneficial effects using the combination of fluoride application and laser irradiation. The aim of this study, therefore, was to evaluate whether Er:YAG laser irradiation either alone or combined with APF application (before/after) could prevent demineralisation of human enamel caused by phosphoric/citric acid, which is common in beverages.

Materials and methods

In the present study, 10 non-carious, recently extracted human third molars were divided into buccal-palatal halves and embedded in acrylic resin blocks. The halves were cut with a hard tissue microtome (Isomet 1000, Buehler LTD., USA) so as to obtain 5 surfaces from each tooth, and samples...
with a 2x3 mm standardized area. The surfaces were polished using 400 grit silicon carbide paper to obtain flat and smooth surfaces, and were then stored in deionised water at room temperature until used. The obtained 50 enamel surfaces were randomly allocated into treatment groups (N=10 per group). In all groups, the baseline Vicker's hardness of each surface was determined using a mini-load hardness tester (Micro-Vickers, Wolpert Wilson® Instruments, USA). Group 1 was the negative control group, which received no treatment. The samples were kept in a soft drink (20ml/samples) 10 min for the demineralisation process only. In Group 2, acidulated phosphate fluoride gel (APF) (1.23% NaF, pH 3.5) (Denti-Care Denti-Pro Gel, Medicom) was topically applied on the samples with disposable brush tips and left undisturbed for 1 min. Then excess gel was removed with cotton swab and the samples were dried with compressed air for 1 minute and demineralised in the soft drink for 10 min. In Group 3, the samples were first treated with APF gel as described before, afterwards surface treatment was performed under the following irradiation conditions with Er:YAG laser (Fotona Fidelis Plus III) (handpiece no R02) at 10Hz, 1.2 J/ cm² with water cooling in non contact mode which were auto settled by the manufacturer, and then rinsed with distilled water and dried with compressed air. The treated surfaces were then immersed in the soft drink for 10 min. In Group 4 the samples were irradiated with Er:YAG laser prior to fluoride application and immersed in the soft drink for 10 min. In Group 5 samples irradiated with Er:YAG laser alone and kept in a soft drink for 10 min. The Vickers value of each enamel surfaces was then re-measured.

Results

Statistical methods
All data were processed by NCSS 2007 & PASS 2008 Statistical Software. For the between-group analysis was used the Kruskal-Wallis test for multiple comparisons, while for intra-group analysis was performed the paired sample t test. A value of a P<0.05 was set as level for significance. All groups had a reduction in Vicker hardness after acidic beverage immersion, however the untreated group (Group 1) had a highly significant reduction in microhardness within group (p<0.01), while the other groups showed lower reduction values (Table 1). Although a percentage difference was found in Vickers values between groups, it was not statistically significant (p>0.05). Group 2, Group 3 and Group 4 Vickers reduction in microhardness were still notable but laser combined fluoride groups (Group III and IV) showed slightly better results than laser irradiated alone (Group 2) regarding baseline measures in percentage. However, no statistical difference was found in Vickers value between application of fluoride prior or after laser therapy (Table 2).

Discussion

Erosion lesions are caused by acids with pH as low as 2.6, such as in acidic drinks or those originated from the stomach, like gastric acids from eating disorders and reflux [Lussi et al., 2000; Barron et al., 2003]. Preventive strategies for dental erosion are few and alternative ways to stop the progression of enamel loss are required [Nunn, 1996; Magalhaes et al., 2009]. Several studies have tried to use fluoride to prevent erosion, either by topical fluoride application or even by adding it as a component to beverages [Hughes et al., 2004; Larsen and Richards, 2002]. However, the protective effect of fluoride on erosion is still debated. On the basis of previous works, which showed that laser energy in combination with topical fluoride treatment can increase the resistance of
tooth structure to mineral loss from the organic acids involved in dental caries [Anderson et al., 2000; Flaitz et al., 1995; Vlacic et al., 2007], this in-vitro study planned to evaluate whether the synergistic effect of laser and fluoride produces greater benefits than the treatments performed alone. The mechanism by which the laser-activated fluoride protective effect is achieved has been the subject of much conjecture in the literature. Several physicochemical changes have been suggested to occur during laser-activated fluoride treatment, including deposition of calcium fluoride, formation of micropores in the dental hard tissue, formation of tri-calcium phosphate and phase transformation of hydroxyapatite to fluorapatite, which is more resistant to both strong acids as well as to weaker acids thanapatite or hydroxyl or hydroxyl ions incorporated into its structure [Vlacic et al., 2007]. Continuous-wave or pulsed CO2 lasers, Nd:YAG, argon and diode lasers in conjunction with absorbers and excimer lasers have been used to enhance caries resistance and support remineralisation [Featherstone et al., 1998; Hossain et al., 2001; Santalla et al., 2004]. Despite its main application for cutting dental hard tissues, the use of erbium lasers such as Er:YAG and Er,Cr:YSGG have been also used for preventing enamel demineralisation [Apel et al., 2005; Delbem et al., 2003]. There are few studies available testing the effect of the laser application on the prevention of erosive demineralisation and most of them are related to carious and not erosive demineralisation [Sobral et al., 2009; Vlacic et al., 2007]. Tsai et al. [2002], compared the effectiveness of laser treatment (pulsed CO2 and pulsed Nd:YAG-83.3 J/cm²) on the acid resistance of human enamel in vitro. The Nd:YAG laser was not able to increase the enamel resistance to that acid challenge. In contrast, the application of Nd:YAG laser (0.5, 0.75 and 1 W) combined or not with fluoride application (fluoride gel and varnish) significantly reduced the enamel erosive wear in a 5-day in vitro study [Buzalaf et al., 2008]. Vlacic et al. evaluated the association of high-power laser with fluoride in preventing erosion but the protocol of irradiation and the sequence of fluoride therapy and acid challenge were different from our study [Vlacic et al., 2007]. In both studies lased groups showed promising results against erosive challenge, which is in line with our results that showed that regardless of the order, Er:YAG laser and fluoride were together capable of increasing human enamel resistance to citric acid commonly found in beverages. The ablation threshold of Er:YAG laser was determined by several authors, but no exact parameters were confirmed. The ablation threshold of Er:YAG laser was confirmed for 1 W with a repetition rate of 2 Hz as found by Li et al. [1992] as the threshold of 9 J/cm² with a repetition rate of 2 Hz was found by Li et al. [1992]. However, the actual mechanism of acid resistance by laser with fluoride, and more effective parameters of laser systems are still unclear and studies, particularly in vivo, to test those claims are required.

### References


