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Effects of topical fluoride on primary tooth enamel microhardness after diode laser treatment

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ABSTRACT

Objectives: Tooth decay is controlled and prevented using fluorides. Specifically, a combination of laser irradiation and topical fluoride application can improve fluoride absorption. Although laser irradiation is recommended in traditional technology for caries prevention, little is known about the efficacy of caries-inhibiting laser diodes. Further, most studies have focused on permanent teeth. The objective of this study was to explore the effect of laser diode radiation mixed with topical fluoride on the enamel surface microhardness of primary teeth.

Material and method: The 60 primary teeth were divided into 60 plates. Baseline Vickers microhardness was established for each enamel surface. The samples were then divided into three groups. 4 % NaF varnish (group A) and 4 % NaF varnish using diode 2 and 3 W lasers (groups B and C, respectively). The final microhardness was measured and statistically evaluated using SPSS version 16. ANOVA was used to compare the means of the tested groups, which had a P-value of 0.05, indicating significance.

Result: The mean and standard deviation of microhardness for the different groups was tested. Group C (4 % NaF with a diode laser at 3 W) showed a higher average Vickers hardness (VHN) than Group B (4 % NaF with a diode laser at 2 W), whereas group A showed the lowest average VHN. There was a significant difference in microhardness between groups (P 0.05).

Conclusion: This study explored the effect of laser mixed with topical fluoride on enamel surface microhardness of primary teeth. The use of a diode laser (Quanta System, Italy) with a fluoride varnish applied to the enamel surface has a greater effect on the resistance of the enamel to caries.

1. Introduction

The use of various laser types—such as diodes, argon, and CO_2—in the field of preventive dentistry have been recommended by various studies and laser irradiation is an adjunct to conventional caries preventive treatment (Korytnicki et al., 2006). Through the studies lasers evolved as a potential alternatives for modifying tooth surfaces and improving acid resistance (Esteves-Oliveira et al., 2009). Because diode lasers use fibre optics, they have several distinct advantages over other lasers including lower cost, ease of use, and smaller size. The literature search has revealed that there are a very few studies which examined the effects of diode lasers on tooth enamel hardness (Santaella et al., 2004; González-Rodríguez et al., 2011). Most of the studies using diode lasers focused on permanent teeth, and few researchers aware of the effects of lasers on deciduous teeth in terms of caries prevention.

Although the prevalence of caries has recently decreased in many countries, it remains the most common disease in children (Bahrololoomi and Lotfian, 2015). Therefore, the promotion of dental health should prioritise caries prevention rather than focusing solely on treatment. A new strategy for improving fluoride binding to the tooth enamel involves the use of lasers in combination with fluoride (Villalba-Moreno et al., 2007). Laser light stops the formation of caries on the enamel surface (Apel et al., 2002) and causes decomposition of the organic matrix and formation of calcium phosphate. The mix of fluoride and laser reinforces the bond between fluoride and hydroxyapatite, producing fluorohydroxyapatite and calcium fluoride on the enamel surface that act as a resource area. Fluoride prevents tooth decay during demineralisation (Hsu et al., 2000). The effectiveness of topical fluoride in preventing caries is well-established (Chu et al., 2010; Hawkins et al., 2003; Jacobsen and Young, 2003; Lo et al., 2012). Topical fluoride varnishes, gels, and solutions administered by dentists are beneficial in the prevention and treatment of dental caries but are subject to ease of application, patient preference, and risk of ingestion. Most dentists prefer varnishes because of their efficiency in reduction of dental caries

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(Chu et al., 2010; Hawkins et al., 2003; Jacobsen and Young, 2003; Lo et al., 2012). Recently, fluoride varnishes were shown to prevent tooth decay and early enamel lesion (Xhemnica et al., 2008; Amaechi et al., 2012; Vaikuntam, 2000).

The aim of this in vitro study was to determine the effect of laser diode radiation mixed with topical fluoride on the enamel surface microhardness of primary teeth.

2. Materials and methods

Following extraction, 60 primary molars with no caries (for orthodontic reasons) were cleaned using a detergent. The teeth were stored in distilled water at room temperature. The root of each tooth was removed using a low-speed diamond disc, and the crown was sliced into two parts mesiodistally. Each block was made into enamel slabs (2 × 2 × 4 mm) and embedded in epoxy resin (Alteco, Quick Epoxy Adhesive, Indonesia). Sixty samples were prepared. To create a flat enamel surface, the slabs were serially polished using 300, 600, and 1200 grit silicon carbide sheets and an alumina slurry of 0.2 and 0.05 μm.

All specimens were microhardness tested with a pyramidal diamond indenter for 5 s and a 300 g load on a Vickers microhardness tester (Nexus 4000/60, Innovatest, Maastricht, Netherlands) [Fig. 1]. The microhardness was calculated by subtracting the test force from the surface area of the indent. Each surface was measured three times, and the average enamel microhardness was calculated. Baseline microhardness number for comparison used was 286.23 kgf/mm^2.

The samples divided into three groups of twenty each:

Group A: A 4 % NaF varnish was utilised on surface of enamel (Sultan Topex ®, USA). This group of Group A without the application of laser is the control group for the study.

Group B: On the enamel surface, varnish was applied at a concentration of 4 % NaF, followed by a 2-watt diode laser [Fig. 2].

Group C: On the enamel surface, varnish was utilised at a concentration of 4 % NaF, followed by a 3-watt diode laser [Fig. 3].

Irradiation was performed using a diode laser (Quanta System, Italy) in continuous mode at 980 nm with an exposure time of 15 s. The irradiation distance was set at 5 mm and the optic fibre tip diameter was 320 μm. A holder was used to ensure that the laser handpiece tip on the enamel surface was equidistant. All customary safety precautions were followed during laser application.

Fig. 1. A microhardness tester.

Fig. 2. 2 W Diode 980 nm.

Fig. 3. 3 W Diode laser (980 nm).

The fluoride varnish on the specimen surfaces was removed with an electric toothbrush (Oral-B Laboratories Inc., Iowa City, IA, USA) for 5 s after 24 h of storage in distilled water, and then rinsed with distilled water (30 s). The microhardness was measured under identical conditions to the previous measurement, and the results were recorded.

Repeated measures analysis of variance (ANOVA) was used to compare microhardness variations following treatment between the three groups. Statistical analyses were performed using SPSS version 16 (IBM, Armonk, NY, USA).

3. Results

Table 1 shows the mean and standard deviation of microhardness for the different groups. Group C (4 % NaF with a diode laser at 3 W) showed a higher average Vickers hardness (VHN) than Group B (4 % NaF with a diode laser at 2 W), whereas group A showed the lowest average VHN. The differences among groups [A, B, and C] was significant (P 0.05).

Table 1
The mean and standard deviation of microhardness for different groups.

Groups	Baseline Microhardness Mean	SD	Final Microhardness Mean	SD	Microhardness Change Mean	SD	P-value
Group A	286.23	64.717	385.25	49.20	99.02	55.41	0.010***
Group B	318.46	70.596	421.23	32.15	102.77	64.23	
Group C	338.33	59.580	431.17	21.76	92.84	44.75	

4. Discussion

Fluoride is a well-known, thoroughly researched, and effective method for preventing caries. The ability of fluoride to inhibit the onset and progression of tooth decay is behind its successful caries prevention (Gorton and Featherstone, 2003). Researchers have studied the use of diode lasers on tooth enamel surfaces since the 1970s. Laser types produce structural and ultrastructural changes in the tooth enamel (Klim et al., 2000). There are various theories regarding how reactivity occurs in enamel treated with diode lasers (Santaella et al., 2004). The coalescence of microparticles at the surface of tooth enamel is one explanation for decreased permeability (Aoki et al., 2008). Another theory suggests a relationship between diminished porosity and melting, fusion, and recrystallisation of enamel particles, forming bars on the tooth exterior (Schoop et al., 2004). Therefore, the optimal procedure is to use a diode laser before the appearance of a lesion.

Laser irradiation of enamel can affect caries through surface melting and recrystallisation of enamel hydroxyapatite crystals (Featherstone and Nelson, 1987), changes in enamel solubility, porousness (Hsu et al., 2000; Schmidlin et al., 2007), and calcium fluoride deposition (Westerman et al., 1999). This may also have promoted resistance.

The treatment of samples with a 2 or 3 W diode laser combined with NaF varnish improved fluoride uptake by the primary tooth enamel, when in association with controls. This difference was statistically significant because diode laser irradiation resulted in melting and resolidification of the enamel surface of deciduous teeth, making the enamel more resistant to acids using this mechanism. Therefore, it plays an important role in the inhibition of tooth decay.

After evaluating the results of two types of fluoride varnishes in our study, a significant increase in enamel microhardness observed in both sample groups. These results are similar to a study by Nalbantgil D et al., which concluded that microhardness after application of fluoride varnish was greater than that of the control group (Nalbantgil et al., 2013). Sh et al. (2013) in their study, compared the microhardness of the enamel surface between Naf and Amf solutions (Sh et al., 2013). The study showed that fluoride enhances the remineralization process through the cumulative growth of demineralized enamel crystals. AmF compounds have increased microhardness of tooth enamel compared to NaF. Dionysopoulos D concluded in their study that the topical fluoride treatments (0.05 % NaF daily, 0.2 % NaF weekly, and 5 % NaF final topical fluoridation) significantly increased the surface microhardness of tooth enamel after bleaching. (Dionysopoulos et al., 2017). Gatti et al. also concluded that toothpaste with high fluoride concentrations (1100 ppm) and fluoride varnish in combination with toothpaste reduced tooth enamel demineralization compared to the negative control group (Gatti et al., 2011). In a study by Navabi et al. and Maia et al. Frequent use of fluoride toothpaste showed a greater effect on the microhardness of fluoride absorption on the tooth enamel surface compared to the combination with fluoride varnish (Navabi et al., 2011; Maia et al., 2003). A study by Tavassoli-Hojjati et al. showed increased enamel microhardness compared to the control group, which is similar to the present study. They used Iranian APF gel (Kimia). But in a study by Biria et al. Unlike in the present study, fluoride gel (Sina) was not significantly different than the control group with regard to fluoride intake (Biria et al., 2004). Although Duraflor varnish increased enamel microhardness slightly more than Ariadent varnish in this study, there was no significant change in average microhardness between two types of varnish after the procedure ($p < 0.05$). The study by Tavassoli-Hojjati et al. also came to the same conclusion regarding Iranian and foreign APF gel (Tavassoli-Hojjati et al., 2012). Lee et al. investigated the effects of three types of topical fluoride treatment (NaF solutions 2 %, gel-APF, cavity protective varnish) on the remineralization of enamel caries lesions. The study concluded that fluoride treatment regimens have no significant differences in fluoride uptake and reduction in fluorescence lesion area (Lee et al., 2010).

5. Conclusion

This study explored the effect of laser mixed with topical fluoride on enamel surface microhardness of primary teeth. The use of a diode laser (Quanta System, Italy) with a fluoride varnish applied to the enamel surface has a greater effect on the resistance of the enamel to caries.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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