

# Effect of Diode Laser Irradiation Combined with Topical Fluoride on Enamel Microhardness of Primary Teeth

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## Abstract

**Objectives:** Laser irradiation has been suggested as an adjunct to traditional caries prevention methods. But little is known about the cariostatic effect of diode laser and most studies available are on permanent teeth. The purpose of the present study was to investigate the effect of diode laser irradiation combined with topical fluoride on enamel surface microhardness.

**Materials and Methods:** Forty-five primary teeth were used in this *in vitro* study. The teeth were sectioned to produce 90 slabs. The baseline Vickers microhardness number of each enamel surface was determined. The samples were randomly divided into 3 groups. Group 1: 5% NaF varnish, group 2: NaF varnish+ diode laser at 5 W power and group 3: NaF varnish+ diode laser at 7 W power. Then, the final microhardness number of each surface was again determined. The data were statistically analyzed by repeated measures ANOVA at 0.05 level of significance.

**Results:** In all 3 groups, microhardness number increased significantly after surface treatment ( $P < 0.05$ ). However, Microhardness change after treatment was not significantly different among groups ( $P > 0.05$ ).

**Conclusion:** The combined application of diode laser and topical fluoride varnish on enamel surface did not show any significant additional effect on enamel resistance to caries.

**Keywords:** Diode laser; Fluoride; Hardness; Primary teeth

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## INTRODUCTION

Although the prevalence of dental caries has recently decreased in many countries, it is still the most common disease among children. Therefore, prevention of caries rather than treatment alone should be considered as an essential objective for dental health promotion. Fluoride therapy has been proven to be the most effective method of increasing ena-

mel resistance to demineralization [1]. Topical fluoride is able to prevent the development or reverse the progression of initial dental caries [2].

Recently, lasers have provided a new method of caries prevention, and laser therapy has been investigated as an alternative method for modifying the tooth surface and increasing its resistance to acids [3].

Several studies have reported the effect of laser irradiation on tooth enamel, either alone or in combination with fluoride [4-6]. It has been demonstrated that combined application of laser and fluoride has a synergistic effect. Laser enhances the effect of fluoride on enamel structure both superficially by forming calcium fluoride (CaF<sub>2</sub>) and in its crystalline structure [7].

Several types of lasers have been used in combination with fluoride in previous studies. However, it is still unclear which one has the best outcome. Among these lasers, diode laser has a number of unique characteristics such as: low cost compared to other lasers, smaller size and easy application in the mouth because of the optic fibers. But, only a small number of studies have investigated the effects of diode laser on enamel structure [8-10]. Most of these studies have been conducted on permanent teeth and little information is available on caries prevention effect of lasers on primary teeth. It is reported that the pattern of caries development and prevention in primary teeth is to some extent different from that in permanent teeth [11].

Therefore, the aim of this in-vitro study was to evaluate the effect of diode laser irradiation combined with fluoride on primary teeth and to compare the effects of two different powers of diode laser on enamel. As enamel microhardness is correlated to its resistance to caries, we used microhardness test in this study.

## MATERIALS AND METHODS

The teeth used in this study were primary molars extracted in the School of Dentistry of Shahid Sadoughi University of Yazd. Forty-five primary molars were selected among teeth without any visible carious lesions on their buccal and lingual enamel surfaces. The teeth were kept in distilled water at room temperature until used and during the study period. The root of each tooth was separated, and the crown was bisected into two halves, mesiodistally, using a low speed diamond disk provid-

ing 2 blocks (one buccal and one lingual). Enamel slabs (2×2×4 mm) were prepared from each block and then embedded in acrylic resin (totally 90 samples). The slabs were serially polished with 300, 600 and 1200 grit silicon carbide papers and with 0.2 and 0.05 microns alumina slurry, to achieve a flat enamel surface.

The baseline microhardness number of each sample was measured using Vickers microhardness tester (FM 700; Future-Tech Corp, Japan) with a pyramidal diamond indenter under a 50 gr/f load for 5 seconds. The Vickers microhardness number was measured by dividing the test force by the surface area of the indent. Microhardness of each surface was measured 3 times and the average was recorded as the baseline Vickers microhardness number. Then, the samples were randomly assigned to 3 groups each containing 30 samples:

Group 1: Application of 5% NaF varnish (Topex DuraShield, Sultan, USA) on enamel surface.

Group 2: Application of 5% NaF varnish on enamel surface followed by irradiation with diode laser (ARC Laser, Fox Germany) at a wavelength of 980nm with the power of 5 watt.

Group 3: Application of 5% NaF varnish on enamel surface followed by irradiation of the same laser with the power of 7 watt [10].

The parameter settings used for both groups were: The laser was used in pulse mode.

And pulse duration and pulse interval were both 30ms.: 15Hz, optic fiber diameter: 600 μm and exposure time: 30 s. the irradiation distance was established at 5 mm using a custom-made holder and the enamel surface was exposed to the laser in scanning mode.

After 24 h the varnish was removed from the samples with a power tooth brush (Oral-B, Braun) and distilled water. Finally, surface microhardness numbers of all samples were re-measured under the same conditions as mentioned.

### Statistical analysis

The mean and standard deviation of baseline and final microhardness number and microhardness change during treatment was calculated for each group. Microhardness change was calculated by subtracting the baseline microhardness number from the post-intervention number.

Paired sample test was used to check the significant change between before- and after-treatment values in each group. To compare microhardness changes after treatment between the three groups, repeated measures ANOVA was applied as between subject comparison. Statistical analysis was carried out by PASW software (version 18 PASW). Type 1 error was considered as 0.05.

### RESULTS

In all three groups, enamel microhardness increased after treatment and the change was statistically significant in each group (Table 1) ( $P < 0.001$ ).

The results of repeated measures ANOVA showed no significant difference in amount of microhardness change between the three groups ( $P = 0.264$ ).

In other words, microhardness increase was equal and statistically significant in all groups ( $P < 0.001$ ).

### DISCUSSION

The results of this study showed that fluoride application alone or in combination with diode laser irradiation with 5 and 7 W power increased the enamel surface microhardness of the primary teeth.

Several theories have been suggested regarding the mechanisms by which laser irradiation increases enamel resistance to caries, such as surface melting and re-crystallization of enamel hydroxyapatite crystals [12], reduction in permeability and solubility of enamel [13,14], and deposition of calcium fluoride [15]. Many studies conducted using different types of lasers have shown significant enamel and dentin resistance to dental caries. The application of CO2 laser combined with fluoride has been proven to be effective for caries prevention in several studies [7,16,17]. Diode laser is now widely used in dental practice. However, its usefulness in combination with fluoride for caries prevention has been less studied. Moreover, the available data are mostly on permanent teeth [18,19]. It has been shown that diode laser irradiation combined with fluoride application increases fluoride uptake in permanent teeth and thus is an effective method for preventing dental caries [9, 10]. Souza et al. reported that diode laser irradiation induces melting and resolidification of the enamel surface of primary teeth and through this mechanism, it increases the resistance of enamel to acids. Thus, it probably plays an important role in caries prevention [20].

In contrast to our results, Santanella et al. concluded that topical fluoride application improves the resistance of sound enamel more effectively than diode laser application in primary teeth [21]. Enamel surface microhardness is indicative of enamel mineral content and microhardness measurement has acceptable sensitivity to assess enamel resistance to demineralization.

**Table 1.** Intra-group comparison of microhardness

Groups	Baseline Microhardness Mean (SD)	Final Microhardness Mean (SD)	Microhardness Change Mean (SD)	P value *
Group 1(n=30)	367.7 (44.1)	395.9 (53.7)	+28.5 (40.2)	0.01
Group 2(n=30)	376.7 (39.3)	415.0 (41.9)	+38.2 (35.1)	0.00
Group 3(n=30)	396.4 (42.0)	440.6 (46.8)	+44.2 (35.8)	0.00

\* Paired *t*-test (level of significance  $P < 0.05$ )

Studies on the effects of laser on enamel microhardness show controversial results. Florin et al. found an increase in enamel microhardness by laser irradiation [22]. Majori et al. reported no change in enamel microhardness following laser treatment [23]. One study suggested that laser irradiation may decrease the enamel microhardness [24]. These controversial findings are probably due to different laser types, parameters and study settings.

Azevado et al. showed the same results as our study using Nd:YAG laser. They found that Nd:YAG laser was effective in decreasing demineralization depth both alone and in combination with fluoride gel/varnish [25].

However, comparison between the findings of the current study and those of previous studies is not simply possible. One reason is due to different parameters and settings used in the studies. Besides, most available investigations were carried out on permanent teeth. Fluoride may affect the primary teeth differently than permanent teeth.

The results of our study indicated that diode laser irradiation combined with fluoride treatment was able to increase enamel microhardness significantly but had no statistically significant difference from the group treated only with fluoride. We also compared two different laser powers. The amount of microhardness increase in 7 W group was higher than in 5 W group. However, the difference was not significant. It has been shown that the increase in pulp chamber temperature above 5.5° C may cause damage to pulp tissue [26]. Therefore, further studies are required to determine the best laser parameters with acceptable safety. A limitation of this in-vitro study was that it could not exactly simulate the clinical setting and also the effect of acid attacks was not clear.

## CONCLUSION

Diode laser combined with fluoride varnish was not more effective than fluoride alone to increase enamel resistance to demineraliza-

tion. Further in vitro and in vivo studies are required.

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## REFERENCES

- 1- Clarkson JJ. International collaborative research on fluoride. J Dent Res. 2000 Apr;79(4):893-904.
- 2- Marinelli CB, Donly KJ, Wefel JS, Jakobsen JR, Denehy GE. An *in vitro* comparison of three fluoride regimens on enamel remineralization. Caries Res. 1997;31(6):418-22.
- 3- Oliveira M, Zezell DM, Meister J, Franzen R, Stanzel S, Lampert F, et al. CO2 laser (10.6 μm) parameters for caries prevention in dental enamel. Caries Res. 2009;43(4):261-8.
- 4- Can AM, Darling CL, Ho C, Fried D. Non-destructive assessment of inhibition of demineralization in dental enamel irradiated by a lambda 5 9.3-microm CO2 laser at ablative irradiation intensities with PS-OCT. Lasers Surg Med. 2008 Jul;40(5):342-9.
- 5- Hossain MM, Hossain M, Kimura Y, Kinoshita J, Yamada Y, Matsumoto K. Acquired acid resistance of enamel and dentin by CO2 laser irradiation with sodium fluoride solution. J Clin Laser Med Surg. 2002 Apr;20(2):77-82.
- 6- Chen CC, Huang ST. The effects of lasers and fluoride on the acid resistance of decalcified human enamel. Photomed Laser Surg. 2009 Jun;27(3):447-52.
- 7- Chin-Ying SH, Xiaoli G, Jisheng P, Wefel JS. Effects of CO2 laser on fluoride uptake in enamel. J Dent. 2004 Feb;32(2):161-7.
- 8- Santaella MR, Braun A, Matson E, Frentzen M. Effect of diode and fluoride varnish on

- initial surface demineralization of primary dentition enamel: an in vitro study. *Int J Paediatr Dent.* 2004 May;14(3):199-203.
- 9- Villalba-Moreno J, González-Rodríguez A, López-González JD, Bolaños-Carmona MV, Pedraza-Muriel V. Increased fluoride uptake in human dental specimens treated with diode laser. *Lasers Med Sci.* 2007 Sep;22(3):137-42. Epub 2007 Jan 11.
- 10- González-Rodríguez A, de Dios López-González J, del Castillo Jde D, Villalba-Moreno J. Comparison of effects of diode laser and CO<sub>2</sub> laser on human teeth and their usefulness in topical fluoridation. *Lasers Med Sci.* 2011 May;26(3):317-24.
- 11- Sonju Clasen AB, Ruyter IE. Quantitative determination of type A and type B carbonate in human deciduous and permanent enamel by means of Fourier transform infrared spectrometry. *Adv Dent Res.* 1997 Nov;11(4):523-7.
- 12- Featherstone JDB, Nelson DGA. Laser effects on dental hard tissues. *Adv Dent Res.* 1987 Oct;1(1):21-6.
- 13- Hsu CYS, Jordan TH, Dederich DN, Wefel JS. Effects of low-energy CO<sub>2</sub> laser irradiation and the organic matrix on inhibition of enamel demineralization. *J Dent Res.* 2000 Sep;79(9):1725-30.
- 14- Schmidlin PR, Dörig I, Lussi A, Roos M, Imfeld T. CO<sub>2</sub> laser-irradiation through topically applied fluoride increases acid resistance of demineralized human enamel in vitro. *Oral Health Prev Dent.* 2007;5(3):201-8.
- 15- Westerman GH, Hicks MJ, Flaitz CM, Blankenau RJ, Powell GL. Combined effects of acidulated phosphate fluoride and argon laser on sound root surface morphology: an in vitro scanning electron microscopy study. *J Clin Laser Med Surg.* 1999 Apr;17(2):63-8.
- 16- Mohan AG, Ebenezar AR, Ghani MF, Martina L, Narayanan A, Mony B. Surface and mineral changes of enamel with different remineralizing agents in conjunction with carbon-dioxide laser. *Eur J Dent.* 2014 Jan;8(1):118-23.
- 17- Esteves-Oliveira M, Pasaporti C, Heussen N, Eduardo CP, Lampert F, Apel C. Prevention of toothbrushing abrasion of acid-softened enamel by CO<sub>2</sub> laser irradiation. *J Dent.* 2011 Sep;39(9):604-11.
- 18- Yu DG, Kimura Y, Fujita A, Hossain M, Kinoshita JI, Suzuki N, et al. Study on acid resistance of human dental enamel and dentin irradiated by semiconductor laser with Ag(NH<sub>3</sub>)<sub>2</sub>F solution. *J Clin Laser Med Surg.* 2001 Jun;19(3):141-6.
- 19- Kato IT, Kohara EK, Sarkis JE, Wetter NU. Effects of 960-nm diode laser irradiation on calcium solubility of dental enamel: an in vitro study. *Photomed Laser Surg.* 2006 Dec;24(6):689-93.
- 20- De Souza MR, Watanabe I, Azevedo LH, Tanji EY. Morphological alterations of the surfaces of enamel and dentin of deciduous teeth irradiated with Nd:YAG, CO<sub>2</sub> and diode lasers. *Int J Morphol* 2009 27(2):441-6.
- 21- Santaella MR, Braun A, Matson E, Frentzen M. Effect of diode laser and fluoride varnish on initial surface demineralization of primary dentition enamel: an in vitro study. *Int J Paediatr Dent.* 2004 May;14(3):199-203.
- 22- Florin R, Herrmann C, Bernhardt W. Measuring microhardness of laser exposed tooth surface. *Stomatol DDR.* 1990 Feb;40(2):49-51.
- 23- Majori M, Manzon L, Pane S, Bedini R. Effects of Nd:YAG laser on dental enamel. *J Appl Biomater Biomech.* 2005 May-Aug;3(2):128-33.
- 24- Tagomori S, Iwase T. Ultrastructural change of enamel exposed to a normal pulsed Nd-YAG laser. *Caries Res.* 1995;29(6):513-20.
- 25- Azevedo DT, Faraoni-Romano JJ, Derceli Jdos R, Palma-Dibb RG. *Braz Dent J.* 2012;23(2):104-9.
- 26- Zach L, Cohen G. Pulp response to externally applied heat. *Oral Surg Oral Med Oral Pathol.* 1965 Apr;19:515-30.