Effect of Laser and Fluoride Application for Remineralization of the Carious Lesion: A Polarized Microscopic Study

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ABSTRACT

Introduction: The new philosophy of prevention rather than repair and replacement has led to the emergence of new era of preventive dentistry. Fluoride is the most widely applied method of caries prevention that remineralizes the subsurface carious enamel. Lasers have been recently investigated as an alternative for caries prevention and enhances the enamel's resistance to acids. So the present study has been carried out in an attempt to explore the possibilities of the effects and applications of Laser in Preventive Dentistry**.** Study aimed to evaluate the effect of laser irradiation followed by fluoride application alone on remineralization of deciduous teeth.

Material and Methods: 30 deciduous extracted molars were randomly divided into 3 groups and were kept in demineralizing solution for 48 hours and then were exposed to remineralizing reagents of their respective groups. In the first group the demineralized teeth were coated with fluoride varnish for 5 min, the second group teeth were irradiated with laser for 10 sec and the third group teeth were first irradiated with laser for 10 sec and then coated with fluoride varnish and left for 5 min and then all the teeth were immersed in artificial saliva and the 3 remineralizing cycle was performed. The sections were prepared mesio-diastally and observed under polarized microscope.

Result: The images under polarized microscope showed that the area of demineralization zone was drastically reduced in the specimen irradiated with laser and with laser followed by fluoride varnish application as compared to that of fluoride varnish alone.

Conclusion: All the applied treatments were capable of reducing caries progression in dental caries amongst which laser irradiation in adjunct to fluoride application was most effective.

Keywords: Laser and Fluoride Application, Carious Lesion,

INTRODUCTION

In the era of minimally invasive dentistry, the main aim is tissue preservation preferably by intercepting disease progress and preventing disease occurrence. In spite of decline observed in dental caries, it still represents as one of the most prevalent chronic childhood oral disease. Caries is a dynamic process, fluctuating between demineralization and remineralizing process, beginning with the microscopic loss of crystal structure progressing to complete destruction and cavitation.[1] Fluoride has been proven to be an effective treatment for prevention of dental caries by inhibited demineralization and enhancing remineralization.[2] Fluoride therapy either systemically or locally can prevent the initiation and progression of dental caries. Recently, it has been shown that laser irradiation can effectively improve the acid resistance via changes in enamel crystals which can prevent the spread and progress of the carious lesion.[1] The use of lasers in caries prevention was first suggested in 1972 using ruby laser, since then many investigations have been done related to application of lasers in preventive dentistry and has been proposed that the lasers can be used as an adjunct to conventional fluoride therapy.[3] Since enamel is 85% by volume carbonated hydroxyapatite, with 12% water and 3% protein and lipid by volume. So the use of wavelengths that is highly absorbed by water and hydroxyapatite together is expected to generate thermal changes in enamel which will enable the alteration in its structure chemically or morphologically.[4-9] Once the enamel surface is irradiated with laser it causes melting of the enamel crystals and then coalesce to form much resistant crystal called pyrophosphate crystal. In case of fluoride application the enamel crystals i.e. the hydroxyapatite crystals are replaced by fluorapatite crystals which is also a very resistant crystal but not as much as pyrophosphate crystal. Pyrophosphate crystals are completely impermeable barrier that is formed after laser irradiation and it does not allow the acid produced by micro-organism to permeate into the enamel structure. When the enamel surface is irradiated with laser due to the thermal changes produced the crystals of enamel melts and subsequently when the fluoride varnish is applied the fluorapatite crystals also penetrate and gets entrapped in the spaces between the granules. The microspaces formed by laser irradiation may trap the demineralizedions and provide space to allow them to combine with fluoride. The use of fluoride before and after laser irradiation has been shown to increase the fluoride uptake and decreases the amount of solubility in acidic solutions. Study aimed to evaluate the effect of laser irradiation followed by fluoride application as compared to that of fluoride application alone on remineralization in deciduous teeth

MATERIAL AND METHODS

Study was done in Krishnadevaraya College of Dental sciences and Hospital, Bangalore and started on Nov 3rd, 2016. 30 extracted deciduous molar teeth were taken and kept in 0.1M thymol solution for 7 days and the solution was changed every day once. The teeth was thoroughly be cleaned of organic debris with an ultrasonic scaler tip.

Inclusion criteria

30 sound extracted or naturally exfoliated primary molar teeth.

Exclusion criteria

All the decayed, restored, fluorosed, discoloured and the teeth with cracks were excluded from the study.

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Then a 3*3 mm window was prepared on the middle third of the buccal surface of the teeth and the remaining surface of the teeth were coated with different colors of nail varnish. The teeth were then then subjected to demineralization in demineralizing solution for 48 hours at 37 degree Celsius and then they were randomly divided into 3 groups. A demineralizing solution was prepared. The composition of demineralizing solution to be used was as follows:

Demineralizing solution

- 2.2mM calcium chloride ($CaCl_2.2H_2O$)
- 2.2mM monosodium phosphate ($NaH_2PO_4.7H_2O$)
- 0.05M lactic acid

Finally the pH was adjusted to 4.5 with 50% sodium hydroxide (NaOH)

All the samples were then be immersed into a glass container containing 50 ml of demineralizing solution for a period of 48hours at 37degree Celsius. Subsequently, the sections will be cleaned

Group 1 (fluoride): Enamel was treated with fluoride varnish (Fluor Protector®) for 5 minutes

Group 2 (laser): Enamel was irradiated with laser (Waterlase® iPlus™) for 20 seconds

Group 3(laser with fluoride): Laser irradiation (Waterlase® iPlus™) or 10 seconds followed by fluoride varnish over a period of 5 minutes.

Laser etching was done for 10 sec using Er, Cr:YSGG laser (Waterlase® iPlus™) in noncontact mode, at a distance of 15mm with pulse duration of 140µs at 4W energy (60% water 40% air) , 50 Hz energy.

After treating the teeth with their respective group reagents the teeth were immersed in artificial saliva and the solution was changed everyday.

Artificial saliva

- 0.222g/L gastric mucin
- 0.381g/L Sodium chloride
- 0.213g/L Calcium chloride
- 0.738g/L Potassium hydrogen phosphate
- 1.114g/L Potassium chloride.

After 3 cycles of remineralization teeth were sectioned to a thickness of 0.5mm using carborundum disk and each section obtained was visualized under polarized light microscope and statistical analysis was done.

STATISTICAL ANALYSIS

Microsoft office 2007 was used for the statistical analysis. Descriptive statistics like Mean and percentages were used to interpret the data.

RESULT

The results of the study showed that all the applied treatments were able to reduce caries like lesion progression in dental enamel. The present study data revealed that the laser treated samples presented significantly less caries formation than fluoride varnish group. All applied treatments were capable of reducing caries like lesion progression in dental enamel. The present data revealed that the laser treated samples showed less caries formation than other group specimens.

Polarized light microscopic images of the various groups

One sample was studied from each group to observe the demineralization (figure-1).

Area of demineralization after immersing the teeth in demineralizing solution. Black band in the image represents the area of demineralization. The black zone indicates the aresa of dimineralization in this image.

Remineralization observed after fluoride varnish (Fluor Protector®) application. Reduction seen in area of demineralization. there is reduction in the thickness of black zone which is the dimeneralized zone as compared to that of first image (figure-2).

Reduction in demineralized area after Laser treatment (Waterlase® iPlus™).Drastic decrease in the reduction in black band which shows that the lesion has remineralized to a greater extent as compared to that of pervious picture (figure-3) .

Reduction in demineralized area after treating with Laser and fluoride varnish. Disappearance of the black demineralized clearly shows that near total remineralization of the demineralized zone has been achieved by the lesion (figure-4).

DISCUSSION

According to various approaches applied to preventive dentistry in the past, relating to dental caries, certain efforts have been incorporated by chemical means so as to reduce the solubility of enamel surface and create the conditions that would lead to the penetration of the caries preventive agents; fluoride being one of them.

The fluoride concentration and pH of topical fluoride solution have an influence of fluoride uptake into enamel.[10] It works by replacing the hydroxyapatite crystals of tooth into more resistant fluorapatite crystals hence reducing the enamel surface dissolution ability.

Laser pretreatment of enamel can be opted as an alternative to fluoride application, which incorporate subsequent acid-induced dissolution of enamel. The implication of Laser irradiation as a means of inhibiting dental caries was first suggested by Stern and Sognnaes.[2] Recent studies shows that hard tissue applications limits the polymerization of visible light, cures preventive and restorative materials, cavity preparations for restoration placement and tooth whitening procedures as well as includes the laser applications for caries prevention and dentin hypersensitivity.[11-12] It has been reported that lasers improve enamel's resistance to dissolution, enhance microhardness, and lessen invitro caries formation and progression. Laser irradiation use to prevent dental caries depends on physical, chemical and crystalline changes which is induced in enamel because of heating of the surface. The change that takes place in the crystalline structure is that the hydroxyapatite crystals of enamel gets replaced by a very resistant pyrophosphate crystals upon laser irradiation. The cause of re-mineralization has been High energy laser irradiation of enamel alone at a specified wavelength. Also, one theory states that, laser irradiation decreases enamel permeability because of physical fusion of enamel surface microstructure. On the other hand, one theory focused on a combination of reduced enamel permeability with reduction in solubility by melting, fusion and recrystallization of enamel crystallites, that helps in sealing the surface of the enamel. Moreover, reduction in enamel solubility possibly be due to ultra-structural changes

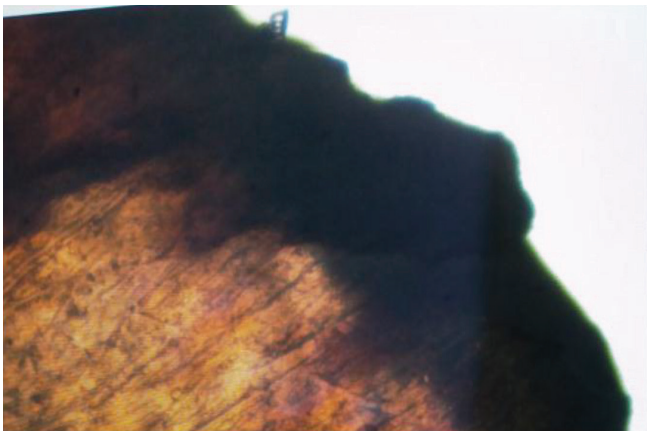

Figure-1: No treatment representative lesion.(Polarized light microscopic magnification × 100)

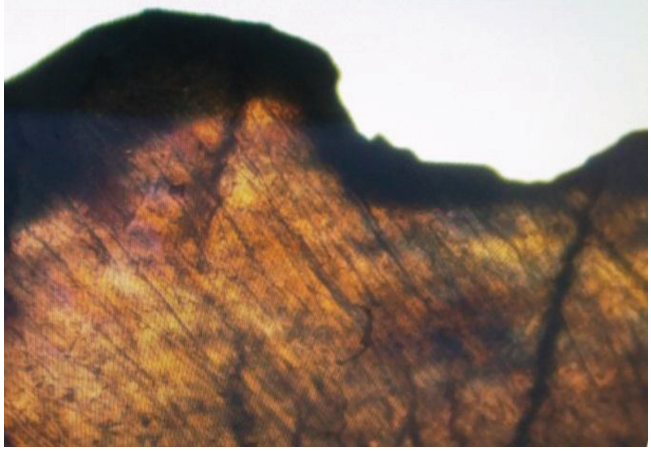

Figure-2: Fluoride varnish application alone representative lesion. .(Polarized light microscopic magnification × 100)

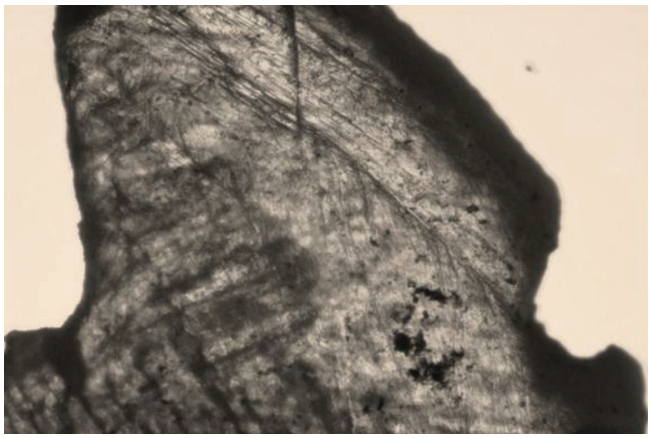

Figure-3: Laser irradiation alone representative lesion. .(Polarized light microscopic magnification × 100)

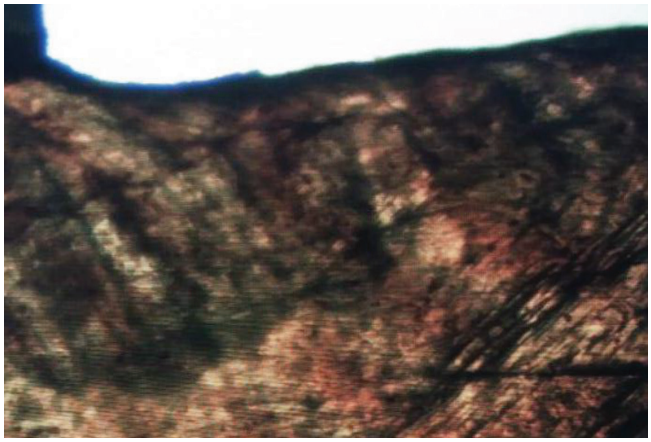

Figure-4: Laser irradiation (Waterlase® iPlus™) followed by fluoride varnish(Fluor Protector®) application representation (Polarized light microscopic magnification × 100).

in enamel crystallography. Reduction of water and carbonate contents, formation of pyrophosphates, and decomposition of proteins have been found. Fowler and Kuroda[7] elaborated the need of a temperature from 100^{0}C to 650^{0}C to promote the photothermal effects that helps in increasing the acid resistance of enamel. Whereas, certain questions comes up like whether the increase in temperature can affect the surrounding tissues and could increase the possibility of pulp damage. Due to this, water cooling was used during the laser irradiation in this study. The results of our in vitro studies have shown that, among the three groups i.e one with fluoride varnish application, one with laser irradiation alone and one with laser irradiation followed by fluoride varnish application the last group had shown the most effective results. The microscopic appearances of the representative caries like enamel lesions from each group were also described in Figures 1-4.The first image (figure 1) shows the area of demineralization after removing the teeth from demuneralizing solution. In Figure 2 there is reduction in the demineralized zone since a part of the lesion is remineralized after fluoride varnish (Fluor Protector®) application. Figure 3 shows drastic reduction in the demineralized area after laser (Waterlase® iPlus™) irradiation for 20 seconds. In Figure 4 the demineralized area has almost disappeared since almost the entire lesion has been remineralized after laser irradiation followed by fluoride varnish application. The present study is limited to the use of just one type of laser i.e. Er, Cr:YSGG laser (Waterlase® iPlus™). Resulting to this, need arises for further researches by keeping into mind the above mentioned study so as to decrease the enamel solubility and also to incorporate increased amount of fluoride into the enamel.

CONCLUSION

As new philosophy emerges for prevention rather than repair and replacement which has become the most recent approaches in preventive dentistry, so the present study has been carried out in an attempt to explore the possibilities of lasers in preventive dentistry. The purpose of this study is to propose the use of laser under controlled environment as a remineralization reagent alone and also in adjunct with fluoride varnish application. Like various other studies, the present study also supports the use of laser and fluoride for the prevention of dental caries.

REFRENCES

1. Malik A, Parmar G, Bansal P, Bhattacharya A, Joshi N. Effect of laser and fluoride application for prevention of dental caries: A polarized microscope analysis. J Dent Lasers. 2015;9:11-5.
2. Wefel JS. Effects of fluoride on caries development and progression using intra-oral models. J Dent Res. 1990;69: 626-33.
3. Korytnicki D, Mayer MP, Daronch M, Singer Jda M, Grande RH. Effects of Nd:YAG laser on enamel microhardness

and dental plaque composition: an in situ study. Photomed Laser Surg. 2006;24:59-63.
4. Featherstone JDB, Barret-Vespone NA, Fried D, Kantorowitz Z, Lofthouse J. CO2 laser inhibition of artificial caries-like lesions progression in dental enamel. J Dent Res. 1998; 77: 1397–1403.
5. Fried D, Featherstone JDB, Visuri SR, Seka W, Walsh JT. The caries inhibition potential of Er:YAG and Er:YSGG laser radiation. Proceedings of the SPIE Meeting, Jan 28–29 1996, San Jose. Bellingham, Washington, pp 73–78.
6. Apfelbaum F, Mayer I, Featherstone JBD. The role of HPO42- and CO32- ions in the transformation of synthetic apatitesto β-Ca5(PO4)2. J Inorg Biochem. 1990; 38:1–8.
7. Fowler BO, Kuroda S. Changes in heated and in laser irradiated human tooth enamel and their probable effects on solubility. Calcif Tissue Int. 1986;38:197–208.
8. Featherstone JDB, Fried D, Bitten ER. Mechanism of laser induced solubility reduction of dental enamel. Lasers in Dentistry. Proceedings of the SPIE Meeting; Jan 28–29 1996, San Jose. Bellingham, Washington, pp 112–116.
9. Featherstone JDB, Fried D. Fundamental interactions of laserswith dental hard tissues. Med Laser Appl. 2001;16: 181–194.
10. Goodman BD, Kaufman HW. Effects of an argon laser on the crystalline properties and rate of dissolution in acid of tooth enamel in the presence of sodium fluoride. J Dent Res. 1977;56:1201-7.
11. Liu JF, Liu Y, Stephen HCY. Optimal Er:YAG laser energy for preventing enamel demineralization. J Dent. 2006;34: 62-66.
12. Ehlers V, Ernst CP, Reich M, Kämmerer P, Willershausen B. Clinical comparison of gluma and Er:YAG laser treatment of cervically exposed hypersensitive dentin. Am J Dent. 2012;25:131-135.

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