

# Laser Application in Prevention of Demineralization in Orthodontic Treatment

Hooman Sadr Haghighi<sup>1</sup>, Mahsa Skandarinejad<sup>2</sup>, Amir Ardalan Abdollahi<sup>3</sup>

<sup>1</sup>Department of Orthodontics, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran

<sup>2</sup>Department of Endodontics, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran

<sup>3</sup>Student's Research Committee, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran

## Abstract:

One common negative side effect of orthodontic treatment with fixed appliances is the development of incipient caries lesions around brackets, particularly in patients with poor oral hygiene. Different methods have been used to prevent demineralization such as fluoride therapy and application of sealant to prevent caries. The recent effort to improve the resistance against the demineralization is by the application of different types of lasers. The purpose of this review article is discussing the effects of laser in prevention of demineralization in orthodontic patients.

**Keywords:** laser; demineralization; orthodontic

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\***Corresponding Author:** Amir Ardalan Abdollahi, Student's Research Committee, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran. Tel: +98-9144091317; Email: ardalan\_2000a@yahoo.com

## Introduction

Orthodontic treatment has been associated with increased enamel demineralization because of increased plaque accumulation around the brackets and more cariogenic bacterial environment<sup>1-3</sup>. The most common place for this demineralization to occur is gingival and middle third of facial surfaces<sup>4</sup>. White spot lesions (WSL) envelope is associated with orthodontic appliances, such as locations for bands, brackets, arch wire or elastomeric ligatures. Moreover, most orthodontic patients are adolescents with poor oral hygiene practices, which increase the likelihood of plaque accumulation<sup>5</sup>. This in turn leads to demineralization<sup>6</sup>. Recent investigations put the incidence of white spot lesions during orthodontic treatment with fixed appliances at 73% to 95%<sup>7</sup>. Nothing is more disconcerting than removing a patient's braces and finding visible WSL which is considered irreversible nature of the tooth surfaces loss,<sup>8</sup> so prevention of demineralization is extremely important

and should include dietary counseling, optimization of fluoride regimens, stimulation of salivary flow rate and particular advice on nondestructive tooth brushing habits<sup>9</sup>. There are different types and methods of prevention of demineralization such as fluoride therapy and application of sealant to prevent caries and fluoride-releasing sealer that is more resistance to toothbrush abrasion<sup>10</sup>. One of the recent efforts to improve the resistance against the demineralization is by the application of the laser<sup>11-12</sup>. The aim of this article review is discussing the effects of laser in prevention of demineralization in orthodontic patients.

### Carbon Dioxide (CO<sub>2</sub>) Laser

CO<sub>2</sub> laser was the first dental laser approved by the US food and drug administration (FDA) and has been successfully used in dentistry fields<sup>13-14</sup>. The Neodymium-Doped Yttrium Aluminium Garnet (Nd: YAG) laser penetrates wet tissue easier than CO<sub>2</sub> and other approved systems include: Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er,Cr: YSGG) and Erbium-Doped Yttrium Aluminum

Garnet (Er:YAG) laser. These systems can be used for both soft and hard tissue procedures<sup>15</sup>. Sognnaes performed the first study, which suggested that dental enamel exposure to ruby laser irradiation increased its acid resistance<sup>16</sup>. There are several theories regarding the mechanism by which laser irradiation enhances enamel resistance<sup>17-20</sup>. One of the theories suggested to explain the effect of CO<sub>2</sub> laser and combination of that with fluoride uptake belongs to Fox et al. Based on their theory thermal treatment with laser convert carbonated hydroxyapatite of tooth enamel to a less soluble mineral. Furthermore, chemical inhibitors by the common ions effect on the fluoroapatitic surface which is more effective on the less soluble laser modified enamel surfaces<sup>17</sup>. In the same way Meurman reported that it is possible to transform hydroxyapatite crystals to fluoroapatite crystals instantaneously in the presence of fluoride using a CO<sub>2</sub> laser<sup>18</sup>. Phan et al hypothesized the mechanism for FAP transformation to be according to the following theory. During the fluoride gel treatment, fluoride ions diffuse through the pores between the enamel rods to deposit and form an F-veneer (a thin layer of fluoride) layer covering all the enamel rods. Following CO<sub>2</sub> laser irradiation, this F-veneer layer and a few additional outer micrometers of the enamel surfaces were melted and recrystallized to rearrange them into a new structure: the fluoroapatite mineral<sup>19</sup>. Tagomori and Morioka reported that laser-modified enamel has an enhanced uptake of acidulated phosphate fluoride and this fluoride uptake was greater when laser treatment was performed before fluoride treatment<sup>20</sup>. Hossain et al reported that the combination of CO<sub>2</sub> irradiation with 2% NaF was more effective in preventing dental caries than CO<sub>2</sub> laser irradiation alone. In addition they suggested that the retention of fluoride solution may also influence the caries inhibition too<sup>21</sup>. There is another hypothesis stating that changes in enamel resistance could result from chemical changes such as reduction in the carbonate content of the enamel surface layer or partial decomposition of the organic matrix<sup>22-23</sup>. The quantitative assessment of demineralization by cross sectional micro hardness testing of laser treated enamel revealed that using a 9.6 μm CO<sub>2</sub> laser irradiation significantly inhibit the formation of carious lesions around orthodontic brackets<sup>24</sup>. One of the concerns in this regard is the probability of the effect of laser irradiation on dental pulp. Goodis reported that there is no harm to pulpal tissue of the irradiated teeth<sup>25</sup>.

### **Er,Cr:YSGG Laser**

In vitro studies in which dental hard tissues were irradiated by Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) laser at high potencies (4-6 W) demonstrated a significant increase in acid resistance. In this regard Hossain et al used an Er,Cr:YSGG laser in the surface of enamel with a power of (67.9 J/cm<sup>2</sup>) pulse energy and reported that irradiation by this type of laser in this power seems to be effective in increasing acid resistance. In observation by SEM it was revealed that the lased areas were melted and seemed to be thermally degenerated<sup>26</sup>. In this condition after acid demineralization, the thermally degenerated enamel had little changes. Based on the results of Qiao study the Er,Cr:YSGG laser irradiation is effective for increasing the acid resistance of dental hard tissue and is not concomitant with thermal side effects<sup>27</sup>. As the results of these studies by irradiation of high energy laser melting occurs in the surface of enamel. In this regard fusion on enamel HAP crystals may be effective in inhibition of enamel demineralization. One of the main concerns in application of high-energy laser is the rising temperature (> 1000 °C) that is potentially harmful to pulp<sup>28</sup>. Kantorowitz and McCormack in their studies reported that surface melting and fusion might not be necessary to increase acid resistance<sup>29-30</sup>.

### **Laser Etching a Way to Decrease Demineralization in Orthodontic Treatment?**

In orthodontic field studies showed that laser etching might be an alternative treatment for enamel roughening<sup>31-35</sup>. Laser etching is painless and does not involve either vibration or heat; also, easy handling of the apparatus makes this treatment highly attractive for routine clinical use, lasing of enamel creates micro cracks that are ideal for resin penetration<sup>36</sup>. Enamel and dentin surfaces etched with Er,Cr:YSGG laser show micro irregularities and no smear layer<sup>37</sup>. Laser etching inhibits caries, and this could be of great importance in orthodontics<sup>38</sup>. Because water spraying and air drying are not needed with laser etching, procedural errors can be reduced and time saved<sup>39</sup>. Laser etching of enamel creates micro cracks that are ideal for resin penetration<sup>40</sup>. Ozer reported that irradiation with a 1.50-W laser produces sufficient etching for orthodontic bonding, but irradiation with 0.75-W laser did not<sup>36</sup>. Surface produced by laser

irradiation is also acid resistant. Laser irradiation of the enamel modifies the calcium-phosphate ratio and leads to the formation of more stable and less acid-soluble compounds, thus reducing susceptibility to caries attack<sup>41</sup>. Enamel etching with phosphoric acid create an etch pattern characterized by surface irregularities and demineralization areas. Because of these demineralization areas, enamel becomes more susceptible to caries attack<sup>5</sup>. Therefore laser etching of enamel might have another advantage to phosphoric acid etching<sup>36-38</sup>. All in all there are some contradictory findings about the use of lasers for enamel etching. Although some researchers agree that laser etching is not suitable for etching enamel<sup>39,42</sup>, others reported that laser irradiation might be useful in this issue<sup>37,40,43</sup>. A laser treatment is only possible in areas accessible by laser. This limits the advantages of occlusal or cervical lesions<sup>40</sup>. Reichmann showed that CO<sub>2</sub> laser with specific range of irradiation conditions (9.6µm) work for prevention of dental caries in enamel in human mouths<sup>44</sup>.

## Conclusions

Laser irradiation is a new method for inhibiting demineralization around brackets and other orthodontic appliances which can be combined by fluoride therapy. Laser etching might be an alternative treatment for enamel roughening and it has some advantages in comparison with regular acid etching, but there are some contradictory findings about the use of lasers for enamel etching and more researches are needed in this issue.

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