Review Article

Laser Application in Prevention of Demineralization in Orthodontic Treatment

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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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Introduction

Orthodontic treatment has been associated with increased enamel demineralization because of increased plaque accumulation around the brackets and more cariogenic bacterial environment[1-3]. The most common place for this demineralization to occur is gingival and middle third of facial surfaces[4]. 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[5]. This in turn leads to demineralization[6]. Recent investigations put the incidence of white spot lesions during orthodontic treatment with fixed appliances at 73% to 95%[7]. Nothing is more disconcerting than removing a patient's braces and finding visible WSL which is considered irreversible nature of the tooth surfaces loss,[8] 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[9]. 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[10]. One of the recent efforts to improve the resistance against the demineralization is by the application of the laser[11-12]. The aim of this article review is discussing the effects of laser in prevention of demineralization in orthodontic patients.

Carbon Dioxide (CO_2) Laser

CO_2 laser was the first dental laser approved by the US food and drug administration (FDA) and has been successfully used in dentistry fields[13-14]. The Neodymium-Doped Yttrium Aluminium Garnet (Nd: YAG) laser penetrates wet tissue easier than CO_2 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[15]. Sognnaes performed the first study, which suggested that dental enamel exposure to ruby laser irradiation increased its acid resistance[16]. There are several theories regarding the mechanism by which laser irradiation enhances enamel resistance[17-20]. One of the theories suggested to explain the effect of CO_2 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[17]. 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_2 laser[18]. 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_2 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[19]. 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[20]. Hossain et al reported that the combination of CO_2 irradiation with 2% NaF was more effective in preventing dental caries than CO_2 laser irradiation alone. In addition they suggested that the retention of fluoride solution may also influence the caries inhibition too[21]. 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[22-23]. The quantitative assessment of demineralization by cross sectional micro hardness testing of laser treated enamel revealed that using a 9.6 µm CO_2 laser irradiation significantly inhibit the formation of carious lesions around orthodontic brackets[24]. 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[25].

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^2) 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[26]. 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[27]. 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[28]. Kantorowitz and McCormack in their studies reported that surface melting and fusion might not be necessary to increase acid resistance[29-30].

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[31-35]. 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[36]. Enamel and dentin surfaces etched with Er,Cr:YSGG laser show micro irregularities and no smear layer[37]. Laser etching inhibits caries, and this could be of great importance in orthodontics[38]. Because water spraying and air drying are not needed with laser etching, procedural errors can be reduced and time saved[39]. Laser etching of enamel creates micro cracks that are ideal for resin penetration[40]. 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[36]. 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[41]. 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[5]. Therefore laser etching of enamel might have another advantage to phosphoric acid etching[36-38]. 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[39,42], others reported that laser irradiation might be useful in this issue[37,40,43]. A laser treatment is only possible in areas accessible by laser. This limits the advantages of occlusal or cervical lesions[40]. Reichmann showed that CO_2 laser with specific range of irradiation conditions (9.6μm) work for prevention of dental caries in enamel in human mouths[44].

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.

References

1. Gwinnett AJ, Ceen RF. Plaque distribution on bonded brackets: a scanning microscope study. Am J Orthod 1979;75:667-77.
2. Corbett JA, Brown LR, Keene HJ, Horton IM. Comparison of Streptococcus mutans concentrations in non-banded and banded orthodontic patients. J Dent Res 1981;60:1936-42.
3. Mattingly JA, Sauer GJ, Yancey JM, Arnold RR. Enhancement of Streptococcus mutans colonization by direct bonded orthodontic appliances. J Dent Res 1983;62:1209-11.
4. Mizrahi E. Enamel demineralization following orthodontic treatment. Am J Orthod 1982;82:62-7.
5. Hess E, Campbell PM, Honeyman AL, Buschang PH. Determinants of enamel decalcification during simulated orthodontic treatment. Angle Orthod 2011;81:836-42.
6. Gorelick L, Geiger AM, Gwinnett AJ. Incidence of white spot formation after bonding and banding. Am J Orthod 1982;81:93-8.
7. Lovrov S, Hertrich K, Hirschfelder U. Enamel Demineralization during Fixed Orthodontic Treatment - Incidence and Correlation to Various Oral-hygiene Parameters. J Orofac Orthop 2007;68:353-63.
8. Steiner-Oliveira C, Nobre-dos-Santos M, Zero DT, Eckert G, Hara AT. Effect of a pulsed CO_2 laser and fluoride on the prevention of enamel and dentine erosion. Arch Oral Biol 2010;55:127-33.
9. Lussi A, Hellwig E. Risk assessment and preventive measures. Monogr Oral Sci 2006;20:190-9.
10. Hu W, Featherstone JD. Prevention of enamel demineralization: an in-vitro study using light-cured filled sealant. Am J Orthod Dentofacial Orthop 2005;128:592-600; quiz 670.
11. Fried D, Zuerlein MJ, Le CQ, Featherstone JD. Thermal and chemical modification of dentin by 9-11-microm CO_2 laser pulses of 5-100-micros duration. Lasers Surg Med 2002;31:275-82.
12. Zuerlein MJ, Fried D, Featherstone JD. Modeling the modification depth of carbon dioxide laser-treated dental enamel. Lasers Surg Med 1999;25:335-47.
13. Dunn WJ, Davis JT, Bush AC. Shear bond strength and SEM evaluation of composite bonded to Er:YAG laser-prepared dentin and enamel. Dent Mater 2005;21:616-24.
14. Usumez A, Aykent F. Bond strengths of porcelain laminate veneers to tooth surfaces prepared with acid and Er,Cr:YSGG laser etching. J Prosthet Dent 2003;90:24-30.
15. Hayakawa K. Nd: YAG laser for debonding ceramic orthodontic brackets. Am J Orthod Dentofacial Orthop 2005;128:638-47.
16. Stern RH, Sognnaes RF. Laser inhibition of dental caries suggested by first tests in vivo. J Am Dent Assoc 1972;85:1087-90.
17. Fox JL, Yu D, Otsuka M, Higuchi WI, Wong J, Powell G. Combined effects of laser irradiation and chemical inhibitors on the dissolution of dental enamel. Caries Res 1992;26:333-9.
18. Meurman JH, Hemmerle J, Voegel JC, Rauhamaa-Makinen R, Luomanen M. Transformation of hydroxyapatite to fluorapatite by irradiation with high-energy CO_2 laser. Caries Res 1997;31:397-400.
19. Phan ND, Fried DS, Featherstone JDB. Laser-induced transformation of carbonated apatite to fluoroapatite on bovine enamel. In: Featherstone JDB, Rechmann P, Fried DS, eds. Proceedings of Lasers in Dentistry V.Bellingham, Wash: Society of Photo-optical Instrumentation Engineers: 1999:233-40.
20. Tagomori S, Morioka T. Combined effects of laser and fluoride on acid resistance of human dental enamel. Caries Res 1989;23:225-31.
21. Hossain MM, Hossain M, Kimura Y, Kinoshita J, Yamada Y, Matsumoto K. Acquired acid resistance of enamel and dentin by CO_2, laser irradiation with sodium fluoride

solution. J Clin Laser Med Surg 2002:20:77-82.

22. Nelson DG, Wefel JS, Jongebloed WL, Featherstone JD. Morphology, histology and crystallography of human dental enamel treated with pulsed low-energy infrared laser radiation. Caries Res 1987;21:411-26.
23. Hsu CY, Jordan TH, Dederich DN, Wefel JS. Effects of low-energy CO_2 laser irradiation and the organic matrix on inhibition of enamel demineralization. J Dent Res 2000;79:1725-30.
24. Nelson GV, Osborne JW, Gale EN, Norman RD, Phillips RW. A three-year clinical evaluation of composite resin and a high copper amalgam in posterior primary teeth. ASDC J Dent Child 1980;47:414-8.
25. Goodis HE, Fried D, Gansky S, Rechmann P, Featherstone JD. Pulpal safety of 9.6 microm TEA CO_2 laser used for caries prevention. Lasers Surg Med 2004;35:104-10.
26. Hossain M, Kimura Y, Nakamura Y, Yamada Y, Kinoshita JI, Matsumoto K. A study on acquired acid resistance of enamel and dentin irradiated by Er,Cr:YSGG laser. J Clin Laser Med Surg 2001;19:159-63.
27. Qiao LY, Yu JT, Jia XY. [A study on acquired acid resistance of enamel and dentine irradiated by Er, Cr: YSGG laser in vitro]. Zhonghua Kou Qiang Yi Xue Za Zhi 2005;40:34-7. Chinese
28. Ying D, Chuah GK, Hsu CY. Effect of Er:YAG laser and organic matrix on porosity changes in human enamel. J Dent 2004;32:41-6.
29. Kantorowitz Z, Featherstone JD, Fried D. Caries prevention by CO_2 laser treatment: dependency on the number of pulses used. J Am Dent Assoc 1998;129:585-91.
30. McCormack SM, Fried D, Featherstone JD, Glena RE, Seka W. Scanning electron microscope observations of CO_2 laser effects on dental enamel. J Dent Res 1995;74:1702-8.
31. de Souza AE, Corona SA, Dibb RG, Borsatto MC, Pecora JD. Influence of Er:YAG laser on tensile bond strength of a self-etching system and a flowable resin in different dentin depths. J Dent 2004;32:269-75.
32. Salama FS. Effect of laser pretreated enamel and dentin of primary teeth on microleakage of different restorative materials. J Clin Pediatr Dent 1998;22:285-91.
33. Martinez-Insua A, Da Silva Dominguez L, Rivera FG, Santana-Penin UA. Differences in bonding to acid-etched or Er:YAG-laser-treated enamel and dentin surfaces. J Prosthet Dent 2000;84:280-8.
34. Stewart GP, Jain P, Hodges J. Shear bond strength of resin cements to both ceramic and dentin. J Prosthet Dent 2002;88:277-84.
35. Shimada Y, Iwamoto N, Kawashima M, Burrow MF, Tagami J. Shear bond strength of current adhesive systems to enamel, dentin and dentin-enamel junction region. Oper Dent 2003;28:585-90.
36. Ozer T, Basaran G, Berk N. Laser etching of enamel for orthodontic bonding. Am J Orthod Dentofacial Orthop 2008;134:193-7.
37. Hossain M, Nakamura Y, Yamada Y, Kimura Y, Matsumoto N, Matsumoto K. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin: ablation and morphological studies. J Clin Laser Med Surg 1999;17:155-9.
38. Klein AL, Rodrigues LK, Eduardo CP, Nobre dos Santos M, Cury JA. Caries inhibition around composite restorations by pulsed carbon dioxide laser application. Eur J Oral Sci 2005;113:239-44.
39. Usumez S, Orhan M, Usumez A. Laser etching of enamel for direct bonding with an Er,Cr:YSGG hydrokinetic laser system. Am J Orthod Dentofacial Orthop 2002;122:649-56.
40. Visuri SR, Gilbert JL, Wright DD, Wigdor HA, Walsh JT, Jr. Shear strength of composite bonded to Er:YAG laser-prepared dentin. J Dent Res 1996;75:599-605.
41. Turkmen C, Sazak-Ovecoglu H, Gunday M, Gungor G, Durkan M, Oksuz M. Shear bond strength of composite bonded with three adhesives to Er,Cr:YSGG laser-prepared enamel. Quintessence Int 2010;41:e119-24.
42. von Fraunhofer JA, Allen DJ,Orbell GM. Laser etching of enamel for direct bonding. Angle Orthod 1993;63(1), 73-6.
43. Bishara SE, VonWald L, Laffoon JF,Warren JJ. Effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2001; 119(6), 621-4.
44. Rechmann P, Fried D, Le CQ, Nelson G, Rapozo-Hilo M, Rechmann BM, et al. Caries inhibition in vital teeth using 9.6-mum CO_2-laser irradiation. J Biomed Opt 2011;16:071405.