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REVIEW ARTICLE

Application of Er:YAG and Er,Cr:YSGG Lasers in Cavity Preparation for Dental Tissues: A Literature Review

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ABSTRACT

The laser has been widely used in many specialties of dentistry and several wavelengths have been investigated as a substitute for high-speed handpiece. The purpose of this paper is to review the literature about the use of Er:YAG and Er,Cr:YSGG lasers in cavity preparation for dental tissues. Despite the differences in wavelength, pulse duration and energy, the morphological characteristics of the irradiated dentin surface with these lasers are comparable, as well as its effects as methods of dental caries prevention. Thus, Er:YAG and Er,Cr:YSGG lasers prepared cavities with similar effects on the dental tissue, however, further investigations about ideal irradiation conditions are needed for both lasers.

Keywords: Lasers, Dental caries, Dentin.

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INTRODUCTION

The modern dentistry and its minimally invasive concepts are supported by the development of innovative materials and advanced techniques.[1] In order to develop new and effective means for removing decay, pioneering investigations of the interactions between the energy of the ruby laser with tooth structure were reported in mid-1960[2-7] and the development of wavelengths laser erbium (Er), better adjusted to the clinical needs for cavity preparation without deleterious effects on the pulp led to further investigations.[8-10]

The laser has been widely used in many specialties of dentistry[11-15] and several wavelengths have been investigated as a substitute for high-speed handpiece.[16,17] The cavity preparation is traditionally done by cutting or abrasion of tooth structure and is based on biological and mechanical principles, using rotary instruments. However, the laser ablation of dental hard tissue for the cavity preparation has attracted many researchers, since it is considered safe, reduces pain and providing comfort in the treatment of patients significantly reducing noise and vibrations in comparison with traditional drills.[18-23] Thus, the yttrium-aluminum-garnet (Er:YAG) (2.94 mm) and erbium, chromium: yttrium-scandiumgallium-garnet (Er, Cr:YSGG, 2.78 mm) lasers have been widely studied due to the interest of its use in dental hard tissues.

The Er:YAG laser is indicated mostly for the preparation of hard tissue cavities due to its ability to remove enamel, dentin, caries and old restorations with minimal thermal side effects, which is a major problem associated with other lasers, such as Nd:YAG and CO_2.[24,25] The active laser medium is yttrium-aluminum-garnet crystal doped by erbium ions, once stimulated emits a wavelength of 2.94 μm, corresponding to the maximum absorption peak of water and hydroxyl radicals present in dental tissue.[26,27]

The Er,Cr:YSGG laser emits photons at a wavelength of 2.78 μm, and is strongly absorbed by water and hydroxyapatite,[28-32] the main components of the dentin and bone.[29-33] This energy, when absorbed by the water, is used to cause rapid vaporization and to create microexplosions in hard tissue, occurring ablation of the bone tissues and tooth.[34-36]

Thus, the purpose of this paper is review the literature about the applications of Er:YAG and Er,Cr:YSGG laser for cavity preparation in dental tissues.

LITERATURE REVIEW

Stimulated by the invention of the laser (Light Amplification by Stimulated Emission of Radiation) made by Maiman,[37] pioneering investigations using ruby laser were reported in mid-1960s.[2,4,6] Also studies were followed by the use of Nd:YAG laser and CO_2 in soft tissue. Studies of the use of Nd:YAG[38-40] and CO_2 laser in soft tissue[41-43] were also reported.

The YAG laser has begun to be investigated since the late ‘80s, as it was able to ablate dental hard tissues and effective removal of caries. Since then, erbium laser systems: Er:YAG and Er,Cr:YSGG with the ability to cut dental hard tissues have been reported.[44-46]

The Er:YAG laser has been increasingly applied in clinical practice,[19,47] and each wavelength has a different rate of absorption and interaction with biological tissues. The efficiency of dental hard tissue ablation by Er:YAG laser is increased compared with other lasers,[44] since it promotes better tissue ablation dental caries due to high permeability and therefore be more humid than the healthy tissue.[20,48] Thus, the maximum laser absorption by water makes selective to carious tissue. The ablation of dental tissue depends on the energy used, number of pulses, repetition rate, irradiation time, cooling and the interaction between laser and substrate.[49,50]

An important characteristic of this device is that the time required for the cavity preparation is often longer than the high-speed drill.[51,52] On the another hand, the use of Er:YAG laser with constant water irrigation produces a minimal, reversible and localized pulp response compared to that generated by high-speed handpiece.[53,54] The use of water spray for cooling the site prevents excessive temperature increases,[55-58] making sure the ablation,[59-61] which does not reduce their effectiveness, since the water flow should be adjusted to irradiation conditions.[62] Thus, the incident energy on the tooth during the irradiation with Er:YAG laser is sufficient to produce only the vaporization of water, being mostly used in the ablation process and a tiny fraction results in heating of the dental structure remaining.[44,63]

The Er,Cr:YSGG is the latest laser introduced in dentistry. In 1995 a study was carried out[64] varying its energy density and exposure time to remove the contaminated tissue. Furthermore, the quantity and types of bacteria in the remaining tooth structure were evaluated.

Numerous surveys have also been developed in other areas of dentistry, demonstrating the different applications of this device, such as preventive therapies,[65] cavity preparation,[66-68] endodontic procedures,[69,70] periodontal and peri-implant surgery.[71-73]

This laser produces microexplosions during tissue ablation, resulting in macroscopic and microscopic irregularities.[74] Previous studies have shown that these microexplosions are able to remove the particles of hard tissues of the irradiated areas, resulting in a rough surface with open dentinal tubules without smear layer.[75,76] When the dental hard tissue is irradiated by Er,Cr:YSGG laser with water spray, not only the temperature is suppressed but also cutting efficiency increases.[62]

DISCUSSION

Different studies have shown that, despite differences in wavelength, pulse duration and energy,[77] the morphological characteristics of the dentin surface irradiated with the Er:YAG and Er,Cr:YSGG laser are comparable[76] as well as its effects as methods for preventing dental caries.[78] Clinically, the preparation of hard tissue with Er,Cr:YSGG or Er:YAG is acceptable, since it is properly used water cooling.[48,56]

Morphological aspects of the surfaces prepared with these lasers as similar micromorphology,[76] open dentinal tubules,[79] preferential removal of intertubular dentin[56] and maintenance of peritubular dentin[74] associated with the absence of thermal damage can improve the adherence to irradiated tissues.[57] However, some microcracks from irradiation may hinder the adhesion on these surfaces.[80]

An important factor for the selectivity of the tissue removed during preparation with either Er:YAG and Er,Cr:YSGG lasers is the largest amount of water present in the carious dentin, and in turn the ablation of this tissue is more intense that the healthy dentine when using the same amount of energy,[60] thereby allowing selective removal of infected dentin.[81]

Thus, the Er:YAG and Er,Cr:YSGG lasers perform similar cavity preparation with similar effects on the dental tissue.[76]

CONCLUSION

The laser technology has a promising future in dental practice, however, further investigations are needed to clarify the ideal irradiation conditions for cavity preparation with both lasers.

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