Cavity preparation using hard tissue lasers in Operative Dentistry

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INTRODUCTION

A laser is a device that delivers coherent, monochromatic and collimated light as a form of energy. Most dental laser devices emit invisible light in the infrared portion of the electromagnetic spectrum. On May 7, 1997, the Food and Drug Administration (FDA) cleared for marketing in the United States the first erbium: yttrium - aluminum -garnet, or Er: YAG, laser for use in preparing cavities in the teeth of living human subjects.[1]

Unlike Soft Tissue laser light energy which is transformed into heat transmitted to targeted tissues (photothermal effect), the Erbium laser energy at 2940 nm is highly absorbed by both water and hydroxyapatite, which are some of the components of dental tissues. The laser energy immediately vaporizes the water in the tissue, causing it to expand, resulting in micro-explosions and expulsion of the targeted material. The laser can thus more rapidly remove tooth structures with higher water content. This is an advantage in the management of caries since the lesions have greater water content than healthy structures, allowing preferential removal of the diseased part of the tooth. Since the water absorbs the Erbium laser radiation so well, the temperature rise of the tissue is low and the interaction is limited to the surface of the tissue, with a very shallow depth of penetration, making the laser safe in use.[1] The Erbium lasers have a tooth removal thickness of less than 300µm as compared with the more than 1000-2000µm removed by dental handpieces.[2]

As some conduction of heat cannot be avoided, the Erbium laser includes a water spray delivered through the laser tip, used for cooling the target tissue. Thus little to no heat is generated and tissue thermal damages are avoided. It has also been proven that the addition of water increases the rate of ablation and produces a more desirable surface morphology. Spray air/water levels can be adjusted according to the treatment type.

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ACRONYMS

Er:Cr:YSGG:	Erbium-chromium-doped yttrium scandium gallium garnet
Er:YAG:	Erbium: yttrium- aluminium –garnet
Nd:YAG:	Neodinium-doped yttrium aluminium garnet

The FDA - approved Centauri Er: YAG laser (Premier Laser Systems, Inc.) was cleared for incisions, excisions, vaporization, ablation and haemostasis of soft and hard tissues in the mouth. These provisions included caries removal, cavity preparation and modification of dentine and enamel before acid etching for increased bond strength.[1]

DISCUSSION

Comprehensive studies have been conducted on the effects of the Er: YAG laser on the pulp and the hard dental tissues.[1] When cavity preparations were performed on extracted teeth, the pulpal temperatures remained well below the safe temperature of 5.5°C, in fact less than 3°C.[1,3,4] This is in contrast to temperature changes associated with a dental handpiece, which may be as high as 15ºC.[2] Investigators then conducted *in vivo* animal studies and reported that the pulpal response to cavity preparation with an Er:YAG laser was minimal, reversible and comparable to (or less than) the pulpal response created by a high-speed drill.[1] The reason for the low temperature change is that the ablation of the tooth structure allows the dispersion of heat with the plume formation. The studies have also demonstrated the value of water spray in conjunction with the Er:YAG laser. Not only does water spray help cool the tooth during ablation (as with a high-speed drill), but the efficiency of the process is increased. The survey further reports that 46 studies have shown that the Er:YAG laser alone, or combined with acid etching, produces a surface similar to acid-etched surfaces and that the bond strength when bonding composite to that treated tooth structure is equal to or better than that produced by acid etching alone.[1] Examination of the dental structures after ablation of enamel and dentine with different Er.YAG laser settings, has shown exposed enamel prisms, a dentine surface without a smear layer as well as opened dentinal tubules.[5]

Two key advantages of laser-based systems are their sensitivity and the lack of attendant risks of ionizing radiation. This has allowed their frequent use for monitoring lesions of dental caries and dental erosion. A considerable international research effort is focused on developing new laser applications for dental practice, and each year several large meetings are held which bring together this research.[6] Research has proven that the lasers promote better healing and reduce inflammation in soft tissue procedures.[7,8] The Er: YAG laser also confers great advantages when used in operative dentistry to ablate hard tissue.[9] The Erbium lasers, for example, produce absolutely no vibration as there is no need for contact of the laser tip with the tooth structure.[3] The vibratory noise generated by a handpiece is more than 120dB/vibration.

Comparison of the effects of the Er;Cr:YSGG laser and of different cavity disinfection agents on the micro-leakage of current adhesives has shown no differences when the techniques are tested with etch and rinse adhesives.[10] The combined treatment of laser irradiation together with fluoride prompts an accelerated fluoride uptake with a resultant reduction in the progression of caries-like lesions.[11]

CONCLUSION

Patients prefer the comfort, silence and lack of vibration of lasers whilst there are also the added benefits such as disinfection and reduced pulpal temperature compared with high-speed drills.[12]

In conclusion, Erbium lasers have long been recognized as the optimal dental lasers for effective, precise, and minimally invasive ablation of dental tissues. However, hard tissue lasers are categorised as Class IV and all the prescribed safety regulations should be observed, in consultation with appointed laser safety officers.[13,14]

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