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Lasers in Restorative Dentistry: An Overview

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ABSTRACT

Laser is monochromatic man-made single-photon wavelength. They differ from “white light”, which is a continuum of light of many different wavelengths such as visible colors, infrared (heat) and ultraviolet wavelengths. Wavelength of lasers used in dentistry range from 488nm to 10,900 nm and are also depicted on the electromagnetic spectrum. Depending on the usage, several laser wavelengths are used in dentistry. Lasers were first used in dentistry in 1960’s by Miaman. Lasers in restorative dentistry are used for sealing pits and fissures, Argon(488nm-514nm) and Helium-Cadmium lasers are effective in detecting initial caries. Nd:YAG(1064nm) lasers are used for removal of decayed tooth material however Er:YAG(2940nm) laser is used more on hard tissues. The lasers have replaced retraction, permitting visualization of the prepared margins of the crowns. They prevent secondary caries from developing along the margin and thus decrease the possibility of post cementation sensitivity and also hypersensitivity. Lasers are being used as sources for rapid curing of composite resin restoration. Lasers also find use in bleaching vital and non-vital teeth. Currently, lasers are used in conjunction with other methods, it is expected that specific laser technologies will become a critical component of contemporary dental practice in future.

Keywords : Lasers , Restorative dentistry, Er:YAG , Argon , Nd:YAG

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INTRODUCTION

Lasers have been available in the dental market for almost 25 years now. Lot of clinical research and studies have been conducted in the field of lasers in dentistry,still they are not widely used in most part of the world.This article is an overview of LASERS IN RESTORATIVE DENTISTRY.The types of lasers (and their wavelength), safety considerations and clinical functions of lasers in restorative dentistry is discussed.

LASER – 'Light Amplification by the Stimulated Emission of Radiation'. Introduction of lasers in dentistry, by Miaman in the 1960s - led to continuous research in the field of dental lasers and its applications in dentistry.[1] The standard treatment techniques for caries removal and for cavity preparation using conventional mechanical methods is quite often accompanied by anxiety, fear and pain in most patients. Even though the pain can be reduced by local anesthesia, the fear of needle and noise and the vibrations of the mechanical preparations remain a cause of uneasiness and distress in patients [2],possibly a factor for inspiring early interest of lasers in dentist. Due to its ease, efficiency, specificity, comfort over the traditional conventional methods, lasers are indicated in wide variety of procedures in dental practice. [1].

Table 1: LASERS IN RESTORATIVE DENTISTRY

Laser type[3]	Construction[3]	Wavelength[3]	Waveform[4]	Delivery system[3]
Argon	Gas laser	488nm, 515nm	Pulsed or Continuous	Optical fibre
Diode	Semiconductor	635nm,670nm,810nm 830nm,980nm	Pulsed or Continuous	Optical fibre
Nd:YAG	Solid state	1064nm	Pulsed	Optical fibre
Er,Cr:YSGG	Solid state	2780nm		Optical fibre
Er:YAG	Solid state	2940nm	Pulsed	Optical fibre, Waveguide articulated arm
CO_2	Gas laser	9600,10600nm	Gated or continuous	Waveguide, articulated arm

Lasers find numerous number of application in the field of restorative dentistry.[5]At Forsynth Dental Care, Boston , Lobne and Colleagues carried out initial experiments on dental lasers and are regarded as the pioneers in the use of lasers in dentistry . There initial experiments with CO_2laser irradiation to tooth enamel caused small amounts of hydroxyapatite to be converted to the more insoluble calcium orthophosphate apatite. Enamel's surface becomes impermeable and this reduces subsurface demineralization of enamel.[6]This led to the way for its widespread use in the prevention of caries.

CARIES DETECTION USING LASER ENERGY

Caries diagnosis has always remained visual and tactile, and thus highly subjective. Caries management is the most important duty of the dentist. [7] Laser light are used in the

visible region (blue or red) as a tool for the detection of dental carious lesions. Techniques developed so far, for early caries detection by laser light rely on fluorescence coming naturally from the tooth material or from bacterial by-products [8] called porphyrins will fluoresce red. There is a direct correlation between intensity of the fluorescence and occurrence and magnitude of the caries activity.

Number on the scale of the captured device is directly proportional to the acid attack the tooth undergoes. Therefore, the more acid attack the tooth undergoes, the higher the number on the scale of the capture device. [7]

Pioneer in the area of caries diagnostics -The DIAGNODENT (655 nm diode laser light)[9] is a portable device that measures fluorescence on a scale of 0-99. Diagnodent has a small probe , thus for a coverage areas for example maxillary or mandibular molar , multiple reading needs to be recorded for each pit or fissure in the tooth , thus it is technique intensive . There were many stated issues with early laser fluorescence devices that Spectra Caries Detection Device had to deal with .Which led to a device that is portable, efficient and provides significant patient impact and excellent documentation of the tooth's carious status. It has a wand that integrates with almost all digital imaging software via a Twain interface. Thus due to it plug and play property , operator can quickly disconnect the unit from one computer and connect it to the other computer.[7] Once the image has been taken by Spectra Caries Detection Device , it maps the fluorescence in different colors , depending on the intensity. It scales the propriety algorithm from 0-3 . Reading of 1indicates that acid attach is confined to enamel. [7]

CARIES PREVENTION USING LASER ENERGY

In current scenario, there is a need to prevent dental caries and search for alternatives for the caries prevention and/or new ways of augmenting current caries preventive programs. Lasers are one of potentially effective caries preventive measure used currently.[10] Few In-vitro studies have shown that composition of hydroxyapatite mineral teeth can altered making it strongly resistant to subsequent acid attack in the caries process . Specific laser irradiation are absorbed by carbonated hydroxyapatite minerals which heats the surface briefly, thus the changed are produced. [18]

LASERS IN CARIES REMOVAL AND CAVITY PREPARATION

Currently, several types of lasers with similar wavelength are used for caries removal and cavity preparation . They are present in the middle infrared region of the electromagnetic spectrum. The Er:YAG(2940nm) , Er:YSGG(2790nm) , ER,CR:YSGG (2780nm) are used for cavity preparation – they rely on water based absorption for cutting enamel and dentin . As they are water based, ablation is greatest for Er:YAG laser.[11,12].Clean , sharp margin in enamel and dentin are produced by Er:YAG laser. .As the depth of energy penetration is negligible [13,14] pulpal safety is not a major concern.[15].When Er:YAG are used for caries removal or cavity preparation, patients don't require local anesthesia.[2]Thus they have an added advantage.

Er,Cr:YSGG have several application like enamel etching[16,17,19],caries removal[19]and cavity preparation.[20]Er,Cr:YSGG laser produces rough surface in enamel and in dentin without any significant cracking. In dentin smear layer is removed which thus suggest good bonding results.[17]Even with Er,Cr:YSGG laser , operator need not administer local anesthesia in patients for caries removal or cavity preparation. Er, Cr:YSGGproduces bond with with a wide range of strengths , which sometimes can be unreliable. Thus they have a disadvantage involving etching results.[21]Melting enamel with Er,Cr:YSGG laser increases resistance to acid demineriation.[22]

Incipient enamel caries can also be removed by Nd:YAG lasers even though they are not as efficient as Er,Cr:YAAG,Er:YAG or Er,Cr:YSGG lasers[23].They operate at the wavelength of 1064nm.[24]Nd:YAG has greatest depth of penetration of all available dental lasers , thus chances of unwanted collateral damage , in underlying bone or dental pulp tissue are more as tissue under the surface are exposed to laser energy.[23]

LASERS IN PHOTO-POLYMERIZATION OF RESTORATIVE MATERIALS

Research on photo polymerization of composite resin restorative material using lasers started in early 1980s. One research focus has been the use of the argon laser in this context.[25] For initiation of polymerization of composite resin , the wavelength emitted by argon laser is optimal i.e. 488 nm.[26] Activation of the initiator (camphor quinine) by light(wavelength within range of 400-500nm[25,27] polymerizes photo-activated composite resin.[28,29]The broad peak activity of the of the blue light used for polymerization is in the 480nm range.[25,27]Conventional visual light curing units can activate camphoroquinone , but optimum curing power is not achieved, thus the units often fail to meet required challenges presented by complex resin restorations.[30] Over the period of time the hue and brightness parameters of the conventional visual light curing keeps changing , thus they are not uniform. Due to the heat generated by the units, the bulb, the reflector and light tips degrade and the filter gets heated , therefore the spectrum of light slowly gets altered.[30,31] Consistency in the restoration quality and lack of predictability are the consequences of the changes in the unit.[32]This disadvantage can be overturned by use of argon lasers as they do not employ the use of filters. They generate one wavelength monochromatic blue light with band width of only 40 to 45 nm.[26,33]For standard treatment for each patient the brightness of the light can be set to manufacture's specification for optimum efficiency , unique for each brand of composite and lasers can be calibrated before each cure. As the wavelength of light is specific for the work to be carried out ,resin is cured effectively even though less power is put out by argon laser unit than the convention visual light curing.[33] With Argon laser the thoroughness and depth of composite resin polymerization are greater when compared to conventional visual light curing aids and also less unpolymerized monomer is found in resin cured by argon laser.[34] Thus physical properties like compressive strength , diametral tensile strength ,transverse flexural strength and flexural modulus of composite resin are enhanced.[34,35] but the wear resistance remains the same in any of the methods.[36]Polymerization with argon laser has demonstrated the potential to improve shear bond strengths in enamel and dentin.[37,38] Along with so many advantages there are few disadvantages of argon laser in relation to polymerization of

restorative material. Even though size and weight of the newly available argon lasers (which can be centrally installed) have improved significantly,they are still cumbersome to carry and occupy considerable space than a conventional visual light unit. The cooling fans are noisy and there is a lag time for 30 second between turning the unit and off and actual light emission .Cost of the Argon laser is high , which isanother factor.[39]

LASERS IN REMOVAL OF RESTORATIVE DENTISTRY

Dostalova *et al*. in 1998 and Gimbel in 2000 showed that cement, composite resin and glass ionomer cement can be removed by Er:YAGlaser. Due to potential release of mercury vapor , lasers are contraindicated in the use to ablate amalgam. Keller et all in 1998 reported that Gold crowns, cast restoration and ceramic material are less absorbed by Er:YAG laser and thus cannot be removed by it . Due to such limitation, there is a need for professional training before the clinical use of the lasers by the operator.[40]

TREATMENT OF DENTINAL HYPERSENSITIVITY

One of the most common complaints in dental clinical practice is Dentinal hypersensitivity. Various conventional methods have been used till date such as application of concentrated fluoride to seal the exposed dentinal tubules. The success rate in dentinal hypersensitivity is greatly increased by the ongoing evaluation of lasers in hard tissue application. Schwartz et all in 2000 patients compared the desensitizing system on cervically exposed hypersensitive dentine. There demonstration showed that desensitizing of hypersensitive dentine with an Er:YAg is highly effective . Maintenance of a positive result is more prolonged than with other agents.[40]

LASERS IN VITAL TOOTH BLEACHING

There is a global demand for white and beautiful teeth. Whitening of teeth has become increasingly popular in recent years as tooth plays a major role in personality and beauty of an individual.[41] The color of the teeth can be improved and corrected with bleaching. A new era of bleaching began with introduction of dental lasers. The goal of bleaching with dental lasers in to achieve power bleaching process and avoid any adverse effects while using the most efficient energy source. Diode [42],Argon , Carbon dioxide lasers are few of the dental lasers which can be used for bleaching.[43] The use of lasers in bleaching increases the formation of hydroxyl radical[43], which speeds up the teeth bleaching procedure . 35% of hydrogen peroxide containing whitening product is applied on the teeth after the lips and after the soft tissue has been protected by applying rubber damn and checks and lips have been protected by check retractor.[44] The whitening agent is then activated with the laser light source.[45.46]. Power bleaching aka bleaching by lasers can result in significant whitening of the teeth after one treatment visit although it may require multiple appointments [47,48] or home bleaching methods. The tooth and the individual factor determines the selection of the bleaching material and the technique to be used. The bleaching agent used and the potential

risk associated with tooth heating need to be considered by the operator before initiating the process.[43]

Gingivolasty

Surgical gingoplasty and crown lengthening procedures are performed to aid in the retention of the prosthesis and to enhance the aesthetics . A healthy periodontium is a key to successful prosthesis. It is necessary to prepare periodontal tissue properly before restorative treatment to ensure good form, function and esthetics of the masticatory apparatus as well as patient comfort. The conventional method of doing gingivoplasty are using scalpel, rotary coarse diamond burs , a periodontal knife , electrodes , chemosurgery and the newer method is the use of lasers.[49] CO_2 , ND:YAG[50] , and semiconductor diode lasers can be used for soft tissue surgeries like gingivoplasty and crown lengthening of the tooth.[49] A faster and more favorable surgical treatment is achieved with the use of lasers. Unpleasant bleeding is caused by conventional scalpel surgery and it is mandatory to cover the exposed lamina propria with periodontal pack for 7-10 days. The damage caused by diode laser is minimal to the periosteum and the bone under the gingiva being treated. A thin layer of epithelium can be removed cleanly by diode laser. Laser wounds are less likely to be inflamed and are sterile[50] with a relatively dry field.[49] Diode laser is an excellent soft tissue laser as it does not contact with dental hard tissue and can performed safely in close proximity to dental hard tissues. Diode laser higher heat generation than Nd:YAG although tissue penetration of diode laser is less than Nd:YAG. Thus they have additional advantages over conventional methods and more patience acceptance.[49]

SAFETY CONSIDERATIONS

With the benefits of lasers , there are some disadvantages as well. The laser machines come with a instruction manual for its best and safe use. The dental practitioner must follow certain essentials. These guidelines are must for safe use of dental lasers. The surgical team and the patient should be mandatory equipped with apposite protective eye wear. The working condition of lasers must be good for better efficiency and to prevent any accidental laser exposure. A warning sign should be put up outside the surgical area with limited entry access [51] and highly reflective instrument or instruments with mirrored surface should be avoided as they can cause reflection of the laser beam.[52]

CONCLUSION

The lasers have found application in various restorative procedures such as cavity preparation, caries removal ,restoration removal , vital tooth bleaching, With more research and literature documentation on advantages and disadvantages of lasers in restorative dentistry , they will be a boon in the field of dentistry. It is expected that specific laser technologies will become a critical component of contemporary dental practice in future.

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