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Review Article

A Review on Lasers in Remineralization of Carious Lesions

Vyshnavi Mulakala[1], Tivanani Venkata Durga Mahendra[2]

[1]Internee, Undergraduate Student, Sree Sai Dental College And Research Institute, srikakulam, India.
[2]Postgraduate Student, Sree Sai Dental College and Research Institute, Srikakulam, India.

Corresponding Author: Vyshnavi Mulakala

ABSTRACT

Introduction: Dental caries are still public health problems, and untreated caries lesions are the most prevalent chronic oral problems. Laser therapy is the minimally invasive treatment approach for remineralization of demineralized tooth structure.
Aim: The aim of the study is to emphasize the various effects of lasers on the remineralization of enamel.
Materials and methods: The use of lasers in preventive dentistry and its effecton remineralizing the tooth structure.
Discussion: the use of lasers in remineralization of carious lesions, its effects on tooth structure, and hazardous effects have been reported.
Conclusion: To have a precise diagnosis and to select a proper and successful laser-assisted treatment modality for remineralization, the clinician should have a comprehensive understanding of the principles and fundamentals of laser and its helpful abilities.

Key words: Dental caries, Demineralization, Remineralization, Laser therapy.

INTRODUCTION

Dental caries is the most common and prevalent disease among all oral diseases. Over the years, dental caries is proven to be the most crucial reason for the missing teeth. As enamel is not a regenerative tissue, prevention of dental caries is better than repair or replacement.

Early detection of demineralization proven to be immediate action needed to prevent the widespread lesion and helps to provide preventive and therapeutic interventions that help in reversing the process of demineralization. Pit and fissure sealants, Fluoride application, and LASERS played a marked role in the prevention of dental caries.

Fluoride is the most widely accepted method of caries prevention that helps in mineralizing the demineralized tooth surface. Laser irradiation is proven to be a new method in the removal of dental caries by preventing and enhancing the enamel's resistance to acids, as an aid in placing tooth-colored restorations and as an adjunct in root canal procedures, such as pulpotomies. [1]

The use of lasers in preventive dentistry and has been proposed that the lasers can be used as an adjunct to conventional fluoride therapy in remineralizing the tooth structure. [2] There are six basic types of lasers now are used in dentistry namely CO2 Laser, Nd:YAG Laser, Diode Laser, Argon Laser, Er: YAG, Er, Cr: YSGG Laser, Ho: YAG Laser, amongst these CO2 lasers, enhances the

resistance of the enamel and dentin and thereby reduces demineralization. [3]

AIM:

1) The objective of the study is to emphasize the various effects of lasers on the remineralization of enamel and how lasers used to treat the most deliberately threatening cause of missing teeth.

2) The present literature attempts to explore the effects and applications of Laser in remineralizing the tooth structure, thereby an essential aid in preventive and therapeutic dentistry.

Types of Dental Lasers

Lasers applied in dentistry are named after the chemical elements, molecules, or compounds that compose the active medium, which is stimulated. [4]

History of the Development of the Laser

Date	Name	Achievement
1916	Albert Einstein	Theory of light emission. Concept of Stimulated Emission.
1951	Charles H Townes	The inventor of the MASER (Microwave Amplification of Stimulated Emission of Radiation) at Columbia University - First device based on stimulated emission, awarded Nobel prize 1964.
1951	Alexander Prokhorov Nikolai G Basov	Independent inventors of MASER at Lebedev Laboratories, Moscow. Awarded Nobel prize 1964
1957	Gordon Gould	The first document was defining a LASER, notarised by a candy store owner. Credited with patent rights in the 1970s.
1958	Arthur L Schawlow Charles H Townes	The first detailed paper was describing "Optical MASER." Credited with the invention of LASER. From Columbia University.
1960	Theodore Maiman	Invented the first working LASER based on Ruby. May 16th, 1960, Hughes Research Laboratories.
1961	A G Fox and T Li	Theoretical analysis of optical resonators at Bell Labs.
1961	Ali Javan William Bennet, Jr. Donald Herriot	Invented Helium-Neon (HeNe) LASER at Bell Labs.
1962	Robert Hall	The invention of semi-conductor LASER at General Electric Labs.
1964	J E Geusic H M Markos L G Van Uiteit	The inventor of first working Nd: YAG LASER at Bell Labs.
1964	Kumar N Patel	The inventor of CO2 LASER at Bell Labs.
1964	William Bridges	The invention of Argon Ion LASERS, a Hughes Labs.
1966	William Silfvast Grant Fowles and Hopkins	First metal vapor LASER - Zn/Cd - at University of Utah
1966	Peter Sorokin, John Lankard	First Dye Laser action demonstrated at IBM Labs.
1970	Nikolai Basov's Group	First Excimer LASER at Lebedev Labs, Moscow, based on Xenon (Xe) only.
1974	J J Ewing and Charles Brau	First rare-gas halide excimer at Avco Everet Labs.
1980	Geoffrey Pert's Group	First report of X-ray lasing action, Hull University, UK.
1980	Yamamoto and Sato	Nd: YAG laser was first reported to be used in dental caries prevention
1981	Arthur Schawlow Nicolas Bloembergen	Awarded Nobel Physics Prize for work in non-linear optics and spectroscopy.
1989	Myers and Myers	Development of a pulsed Nd: YAG laser, made application of laser in general dentistry possible.
1990	Ho: YAG, Er: YAG, Argon, Er: YSGG, and other types of laser were invented. The laser has been widely applied in dentistry	

Mechanism of lasers on demineralized tooth: [5]

The Laser is directed on the rotten area, which contains more water molecules than the rest of the tooth

↓

Water molecules in the decay are heated rapidly. Pressure increases and the rotten area "explodes" making a popping sound

↓

The Laser kills bacteria in the area leaving the tooth surface sterile

There are several theories regarding the technique by which laser irradiation enhances enamel resistance. [7-11] One of the theories suggested explaining the effect of carbon dioxide laser and combination of that with fluoride uptake by Fox et al. Based on their thermal theory treatment with Laser convert carbonated hydroxyapatite(HA) of

tooth enamel to a less soluble mineral. Furthermore, chemical inhibitors by the common ions affect the fluorapatite surface, which is more active on the less soluble Laser modified enamel surfaces. [7]

Neuman reported that it is possible to transform hydroxyapatite(HA) crystals to fluorapatite crystals instantaneously in the presence of fluoride using a CO2 laser. [8] Phan et al. hypothesized the technique 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 layer covering all the enamel rods. Following CO2 laser irradiation, this F veneer layer and a few additional outer micrometers of the enamel surfaces were melted and recrystallized to reorganize them into a new structure-the fluoroapatite minera. [9] Tagomori and Morioka reported that Laser modified enamel has an enhanced uptake of acidulated phosphate fluoride (APF), and this fluoride uptake was higher when laser treatment was performed before fluoride treatment. [10] Hossain et al. reported that the combination of CO2 Laser with 2% NaF was more potent in preventing dental caries than CO2 laser irradiation alone. In addition, they suggested that the retention of fluoride solutions may also influence the caries inhibition too. [11] There is another hypothesis that studied the changes in enamel resistance could affect chemical transformations, such as a reduction in the carbonate content of the enamel surface layer or partial decomposition of the organic matrix. [12-13]

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 on the surface of enamel with a power of (67.9 J/cm2) 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 have thermally degenerated. [14] In this condition, after acid demineralization, the thermally degenerated enamel had little changes. Based on the results of the Qiao study, the Er, Cr: YSGG laser irradiation is useful for increasing the acid resistance of dental hard tissue and is not concomitant with thermal side effects as the results of these studies by irradiation of high energy laser melting occurs in the surface of the enamel. [15] In this regard, fusion on enamel HAP crystals may be useful in the inhibition of enamel demineralization. One of the main concerns in the application of high-energy Laser is the rising temperature (>1000°C) that is potentially harmful to the pulp. [16] Kantorowitz and McCormack in their studies reported that surface melting and fusion might not be necessary to increase acid resistance. [17-18]

Advantages of lasers: [5]

when compared to conventional scalpel surgeries:

• Its high precision, its reliability, and visual access to the area operated.

• The hemostasis control is high and no harm to the tissue.

• Sterilization of treatment site.

• Patients become free of anxiety and fear and are also beneficial in medically compromised individuals. [5]

• Tissue recovery is fast, with reduced edema, inflammation, and pain.

• It can perform without local anesthesia infiltration or block, but the use of topical anesthesia is necessary. [19]

Disadvantages of lasers: [5]

• The laser beam could harm the patient or operator by direct beam or reflected light, causing retinal burns

• Laser - more expensive

• Need qualified personal

l Lasers can't be used:

l ill cavities located between teeth

l remove defective crowns or silver fillings

l prepare teeth for bridges.

Despite the fact that all the disadvantages lasers had widespread use in every branch of dentistry.

DISCUSSION

The use of lasers in caries prevention was first encountered in 1972 by Stern and Sognnaes [15 diode lasers] using ruby Laser since then many investigations demonstrated the use of lasers in preventive dentistry and has been proposed that the lasers can be used as an adjunct to conventional fluoride therapy in remineralizing the tooth structure. [2]

A Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Laser use in dentistry was suggested approximately 35 years ago, as a means of using energy generated by light to remove or modify soft and hard tissues in the oral cavity. The radiation involved is of nonionizing and does not produce the same effects attributed to X-radiation. [1]

The CO2 Laser is the first type of medical Laser approved by the Food and Drug Administration [FDA] of the US. CO2 Laser enhances the resistance of the enamel and dentin and thereby reduces demineralization. [3] Several procedures recommended using diodes are Surgery (major & minor), Treatment of abscess, Aphthous ulcer, Hemostasis, Curettage, Epulis, Irritation fibroma, frenectomies, Frenectomy, Gingivectomy prior to impression making, Granuloma, Haemangioma, Removal of hyperplastic tissue, Bacterial reduction, Operculectomy, Flap surgery, Excisional biopsy, Retention cyst, Exposure of impacted teeth, Seeping haemorrhage ,Sulcus preparation, Vestibuloplasty, Root end resection, Ankyloglossia, Hypertrophic lesion surgery, gingival contouring, uncovering submerged implants and periodontal surgeries. [5]

The frequent wavelengths used in studies for caries prevention are Nd:YAG (λ = 1.64 μm), Er:YAG (λ=1.94μm), Er,Cr:YSGG (λ= 1.79μm), Ho:YLF (λ= 2.065 μm), Ho:YAG (2.1μm), argon (λ= 488–514 nm), and CO2(λ= 9.6 and 10.6μm). [6]

Laser hazard classification, according to ANSI and UHSA standards. [20]

Class Description

I - low-powered lasers that are safe to view.

IIa - low-powered visible lasers that are hazardous only when Viewed directly for longer than 1,000 sec.

IIb - low-powered visible lasers that are hazardous when Viewed for longer than 0.25 sec.

IIIa - Medium -powered lasers or systems that are normally Not hazardous if viewed for less than 0.25sec without magnifying optics.

IIIb - Medium -powered lasers (0.5W maximum) that can be hazardous if viewed directly.

IV - High -powered lasers (>0.5W) that produce ocular, Skin, and fire hazardous.

Lasers have become an indispensable clinical tool in a dental armamentarium - proper safety measures to be taken by the clinicians in dental practice. Laser parameters play a crucial role in the caries preventive effects of various lasers systems, although higher irradiance of the Laser may better induce remineralization of the demineralized tooth or prevent the tooth from caries incidence.

CONCLUSION

To have a precise diagnosis and to select a proper and successful laser-assisted treatment modality for remineralization, the clinician should have a comprehensive understanding of the principles and fundamentals of Laser and its helpful abilities. When considering the use of lasers in dentistry, the practitioner must use clinical experience, receive proper training, and have familiarity with the device.

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