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Review Article

LASERS IN ORTHODONTICS: A REVIEW

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A B S T R A C T

Dental lasers on the market now that can be used for soft and hard tissue applications in orthodontics. Knowledge of laser properties such as power, wavelength, and timing is required to achieve the desired effects in the target tissue. Laser therapy is useful since it frequently prevents bleeding, and is painless, non-invasive, and rapid. Its primary downside is its exorbitant price. When using laser dentistry equipment, it is critical to take the required precautions to avoid tissue injury. We discussed the main types and characteristics of laser systems used in dentistry, as well as laser applications in orthodontics, adverse effects, and laser system safety in this article.

INTRODUCTION

In the present era of modern dentistry, where technology is bringing sea changes in all the fields, Dentistry and Orthodontics are no exception to this. The technology in dentistry has always been in search of advanced procedures and techniques for diagnosis and treatment that are convenient and patient-friendly. The result of such a quest has led to the introduction of one exciting technology, "The Light Amplification and Stimulated Emission of Radiation-LASER", making great inroads into many fields of medicine and dentistry.

The unique characteristics of lasers make it possible to perform treatment modalities beyond those performed via conventional techniques, which include ablation of biological tissues, hemostasis, pain relief, and even hard tissue surgeries. The usage of this technique in all the fields of Dentistry has also inspired its use in the Orthodontic specialty, resulting in better patient satisfaction, good practice, decreased treatment timings with better treatment results along with pain reduction procedures**.** [1]

History of Laser

Laser' is an acronym for 'light amplification by the stimulation emission of radiation. ALBERT EINSTEIN, American physicists postulate led the foundation for the invention of the Laser and he explained the photoelectric effect in 1917.[1,2] In 1928, RudolfLedenbergreported indirect evidence of stimulated emission.[3]Afterwords, Charles Townes first introduced the device called "MASER" that generates electromagnetic radiation by stimulated emission.[2,4]In 1960, Theodore Maiman introduced the Ruby laser. In 1962, the first semiconductor laser or diode laser was by Robert Hall at General Electric Laboratories. Was introduced.[2]

The first working neodymium-doped yttrium aluminum garnet (Nd:YAG) laser and CO2 laser was introduced by Bell Laboratories in 1964 by Kumar Patel.[2]

Classification of Lasers

According to strength[1]

Hard tissue laser is used for surgical work.

e.g.CO2 Lasers, Nd:YAG lasers, Argon lasers

Soft tissue lasers used for photo biomodulation and analgesia

e.g. He-Ne lasers, Diode lasers

According to their transmission system[1]

Glass fiber system

e.g. CO2 lasers

Mirror system

E.g. Nd:YAG lasers, Argon laser,He-Ne lasers, Diode lasers, Q-switched Nd-YAG laser

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Glass Fiber and Mirror System-Pulsed Excimer Lasers.

Dental lasers can be further classified in terms of the following characteristics:[1,4]

1. **Emission type**: Spontaneous emission or stimulated emission
2. **Output power**: High-powered, mid-powered or low-powered
3. **Active medium:** Liquid, gas or solid-state
4. **Target tissue**: Hard or soft-tissue
5. **Potential biological damage**: Class I, Class II, Class III or Class IV.

Based on wavelength [4]

Wavelength	Laser
195-350nm	Excimer
337nm	Alexandrite
455-515nm	Argon
637nm	He-Ne
655-980nm	Diode
1064nm	Nd:YAG
2100nm	Ho:YAG
10600nm	CO2

According to their clinical application[1]

Laser type	Wavelength	Clinical application
Argon	488,514	Curing and soft tissue desensitization
Diode	800-830, 950-1010	Soft tissue, periodontitis
Nd;YAG	1064	Soft tissue, periodontitis, desensitization, analgesia, tooth whitening and endodontics.
Er;YSGG	2.79	Hard tissue
Er:YAG	2.94	Hard tissue
Co2	10.6	Soft tissue and desensitization

Classification Based on Thermal Interaction of Tissue[1] ***(2)***

Temperature	Tissue effects
42-45	Hyperthermia
>65	Desidesiccation, protein denaturation and coagulation
70-90	Tissue welding
>100	Vaporization
>200	Carbonization and charring

Advantages and Disadvantages of Laser

For surgical procedure of laser, anaesthesia and drilling of soft tissue or hard tissue is not required. The procedure is less traumatic, provides clean field and gives analgesic effect. It reduces post operative scarring and oedema. The healing is faster and itgives rapid regenerative capacity and reduces post operative sensitivity. Introduction of Laser technology provides less chances of metastasis.

Laser technology comes with some disadvantages also, such as it produces beam or reflected light as it may cause harm to the patients or operator. Also, they are expensive and require qualified personal .[4.5]

Application of Laser in Orthodontics

Lasers in Enamel Conditioning

Acid etching is the first step while bonding and proper conditioning of enamel are necessary for bonding of orthodontic attachments on teeth. The Most common method of enamel conditioning is the use of 37% phosphoric acid etching for 15 sec to achieve optimal bond strength, resulting in the formation of rough and irregular surface for retention of adhesive materials..[6]

Sometimes the rough and porous surfaces caused by acid etching are more susceptible to decay. Hence, the prevention of enamel decay is of great significance in Orthodontics since the occurrence of white spot lesions is more common in Orthodontic patients.[3]

Advancement in technology and up-gradation has today caused Laser etching to be a viable alternative to acid etching of enamel and dentin. The laser etching procedure is painless does not involve either heat or vibrations, making the treatment highly engaging for routine use.[6]

Laser etching reduces the smear layer.[7,8] It produces an acid-resistance surface and modifies the calcium-phosphate ratio, reduces the calcium-carbonate ratio and the water and organic content, and also helps in the formation of a more stable product, thus, reducing the chances of acid attack and decay of tooth surface**.**

After laser irradiation, physical changes occur on the enamel surface such as melting and recrystallization of enamel causing the formation of numerous pores and bubble-like structures.[8] It is found to cause thermally induced changes on the enamel surface up to 10-20 micrometer.[9] Time can also be saved with laser etching as water spraying and air drying are not required.

Debonding Procedure

Debonding is the removal of the attachment and all the adhesive resin from the tooth surface and restoring the surface as closely as possible to its pre-treatment condition without inducing iatrogenic damage. While debonding, various techniques have been recommended butthey cause enamel damage due to temperature changes or high magnitude of force.[10,11,12,13] Furthermore, residual composite removal requires special bur which is expensive. Hence, an Orthodontist would like to have a universal tool that allows a traumatic debonding of ceramic brackets. Hence. laser-assisted debonding procedure has proven to be a better alternative.

The use of laserconsists of three mechanisms; thermal softening, thermal ablation, and photoablation. It eliminates problems such as enamel tear-outs, bracket failures, and pain that are encountered during conventional ceramic bracket removal techniques.[14] Additionally, lasers have the advantage of decreasing debonding force and operation time. With the application of laser irradiation, the adhesive resin can be softened, allowing light force to be applied during debonding resulting in a decreased adhesive remnant index.[15]

Three-Dimensional Laser Scanning and Holography

Developing Laser technologies in private practice has modified the diagnosis and treatment planning, to meet the demand of patients as well as doctors, also allowing efficient and convenient storage, retrieval, and sharing of information.

Laser Scanning helps in the production of Orthodontic appliances such as splints, computerized wire bending, e-models, and surgical simulation models without producing models. The self-corrected mechanism of the laser scanner in adjusting for image distortion gives flexibility for clinical research. Laser scanning can be used to produce details about the craniofacial abnormalities, their exact location, and three-dimensional details.[3,16]

Laser holography is an accurate, non-invasive approach for measuring tooth movement in 3 dimensions. When the crown of a tooth is subjected to a force, the stresses generated in the periodontal ligament have important ramifications for the study of orthodontic tooth movement and periodontal disease.[17]

Laser for Welding

The joining of the metal framework is necessary to create an individual orthodontic appliance to achieve efficient treatment procedures. In orthodontics, most of the appliances are fabricated by welding or soldering. Apart from spot welding and pressure welding, laser welding could be used for joining Orthodontic appliances.

In laser welding, Nd:YAG,CO2, and High -power diode laser (HDPL) are mainly used alloys, with an emission of 720-880nm and 940-990nm wavelength.[18]

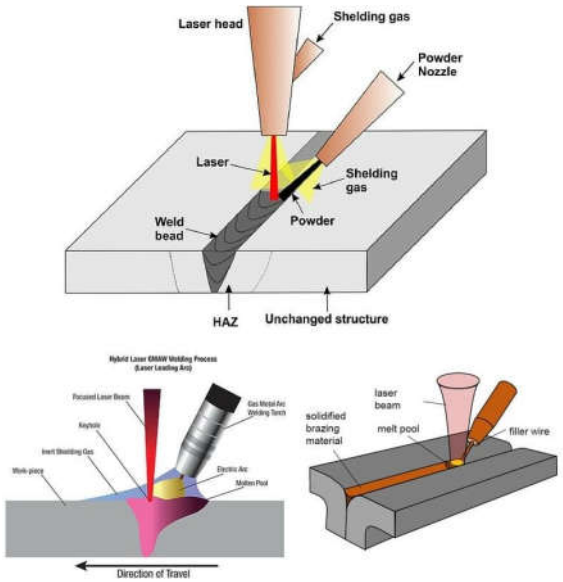

Fig no 1 Laser welding procedure

Laser welding has several advantages such as no corrosion is seen in solder joint and that the surrounding areas do not damage as heating and light are mainly focused at the point of application but sometimes laser welding is accompanied by internal defects such as porosity, voids and cracks leads to brittle nature of the welded area.[19,20]

Laser Used In Prevention of 'White Spot Lesion'

Enameldecalcification is a sequel to orthodontic treatment. Enamel demineralization occurs beneath an intact layer of enamel during fixed orthodontics and around fixed appliances giving rise to a chalky white appearance. Clinically, WSLs in the presence of poor oral hygiene might appear in the 4th week after initiating treatment, resulting in significant changes in the oral environment and leading to a rapid progression of carious decalcification.[21]

White spot formation is considered to be a great problem in orthodontic patients, because it may compromise the aesthetic results of treatment and may also deteriorate tooth health by a progression of a carious cavity. Hence, prevention of white spot lesions and in turn prevention of caries formation is of great importance in Orthodontic patients.

Daily mouth rinse with fluoride, fluoridated products, Casein phospho-peptides-amorphous calcium phosphate (CPP-ACP) are considered as promising agents for increasing enamel resistance to decalcification and also to treat white spot lesions in orthodontic patients. Apart from these, the use of lasers might be a good alternative method for caries prevention, especially in children.[22]

Laser beams lower the dissolution threshold pH value apart from decreasing enamel demineralization. Laser beams lead to changes in surface morphology but maintain an intact enamel surface. Laser beam forms the microspaces within the enamel. These microspaces trap the released ions and serve as sites for remineralization within the enamel surface. Thus, Laser irradiation is a new method for inhibiting demineralization around brackets and other orthodontic appliances which can be combined with fluoride therapy.[22]

Low-Intensity Laser Therapy in Orthodontics

Orthodontic Tooth Movement

Low-level laser therapy (LLLT) is also known as "soft laser therapy" and bio-stimulation. It is the application of light typically within a wavelength of 600 to 1000nm to directly stimulate or inhibit cellular or biological responses.[6]

Low-level laser therapy (LLLT) helps in reducing the treatment duration as Orthodontic treatment can take an average of 14 -24 months treatment time. A longer duration of treatment has often been associated with complications such as white spot lesions, caries, periodontal problems, loss of patient cooperation, and moreover impact on aesthetics and social life and might even lead to discontinuation of orthodontic treatment.

Fig no 2 980nm diode laser for Photobiomodulation

Most commonly used lasers are gallium, and aluminum arsenide diode lasers having wavelengths between 780 to 980nm.Low-level laser therapy seems to be a good choice for accelerating orthodontic tooth movement because it increases bone remodeling that is osteoclastic and osteoblastic without damaging periodontium and it is an easy to use, localized, non-surgical, non-invasive method with no side effects.[23,24]

Orthodontic Pain

Pain or discomfort is the most common and unwanted side effect after application of Orthodontic force during fixed Orthodontic treatment while separator placement, insertion and activation of wire, and during the debonding procedure.

Various methods have been recommended to reduce pain and discomfort such as the use of anti-inflammatory medication, acupuncture, and low-level laser therapy, chewing gum, and

bite wafers. However, these drugs are contraindicated in some patients because these drugs may have side effects such as gastrointestinal problems, thrombocytopenia, skin rashes, renal insufficiency, hypertension, and headaches. Furthermore, most drugs used for pain control can have negative effects on tooth movement if used chronically, due to their inhibitory effects on prostaglandins. Owing to unique advantages in biostimulation LLLT has a therapeutic effect. It is easy to apply and non-invasive and has been used as an option for treating Orthodontic pain as it also has few contraindications or side effects.[3,25,26]

LLLT in reducing pain acts by modifying nerve conduction by affecting the production, discharge, and metabolism of different neurochemicals and reducing the production of prostaglandin levels E2, tumor necrosis factor, plasminogen activator, and (PGE2) and inhibition of cyclooxygenase and mast cell degradation.[26]

Laser Safety

Safety is a fundamental part of providing dental treatment with a laser instrument. It includes regulations and hazard recognition that affect the device, environment, surgical team, and target tissue of the patient. The dental practitioner should be trained to use a specific laser device in accordance with the standard of care. There are three facets to laser safety:

1. The manufacturing process of the instrument
2. Proper operation of the device
3. The personal protection of the surgical team and the patient.

The types of hazards that may be encountered within the clinical practice of dentistry may be grouped as follows:

- Ocular hazard
- Tissue damage
- Respiratory hazards
- Fire and explosion
- Electrical shock
- Combustion hazard
- Equipment hazards

Fig no 3 Laser safety goggles

In Orthodontic practice, before performing any procedure, safety goggles should be worn. Safety goggles protect against the wavelength generated by the laser. The specific goggles shown below to protect against 800–840 nm and 870–1080 nm wavelengths.[27]

CONCLUSION

Lasers have become a ray of hope in dentistry. When used efficaciously and ethically, lasers are an exceptional modality of treatment for many clinical conditions. Laser etching, bio stimulant effects and softening of adhesives during debonding are promising areas of laser use in the clinical Orthodontic practice. Currently, lasers are also predominantly used for research studies in the field of Orthodontics.

To have a precise diagnosis and to select a proper and successful laser-assisted treatment modality for a disease, the clinician should have a comprehensive understanding of the principles and fundamentals of laser and its helpful abilities. In the near future, with the clarification of laser exposure protocols and a decrease in cost, lasers may play an increasingly important role in Orthodontic therapy.

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