Review Article

REVIEW ON ORTHODONTIC LASERS

ABSTRACT: Light amplification and stimulated emission of radiation techniques have been introduced in both medicine and science. Currently many lasers are available which are very efficient for dental soft and hard tissues. To achieve the desirable results, knowledge of laser technology such as power of particular type of lasers, its wavelength, and the time for which the particular laser is used. Lasers are mainly preferred because it prevents bleeding, is pain free and there is no need of intervention and saves valuable time of both patients and specialist, lasers are currently being used for alteration in conventional enamel etching and dentine bonding procedures during composite restorations, laser technology has made an advancement in orthodontics it has known to accelerate the movement of teeth to be moved, lasers are also used for removing the brackets and other bonding procedures, many researchers claim that this technology can also be used for implant procedures like it will increase the stability and strength of implant, reduction in demineralisation of enamel during various procedures. Lasers are mainly used in field of orthodontics which has resulted in better patient co-operation due to reduced pain and discomfort and is also convenient for the operator. Along with the advantages that lasers offer they are associated with few disadvantages. Lasers are relatively higher in prices than conventional equipments, for treating the patients with this modern technology the operator must be specially trained. If not used properly it can cause deleterious effects on tissues. This review article is about various dental lasers, effects of lasers on tissues and clinical and nonclinical applications and laser safety.

Key Words: Lasers, Diode Lasers, CO_2 Lasers, Nd: YAG Lasers, Effects of lasers, Laser Safety

INTRODUCTION

One innovative technology in the light has made significant advances into a variety of fields of dentistry. Because of the unique properties of lasers, therapy modalities such as ablation of soft tissues, haemostasis, alleviation of pain, and dental hard tissue procedures are now possible.[1]

LASER refers for Light Activation by Stimulated Emission Radiation. It is a term that explains how amplification of light occurs by stimulated emission. Lasers are made up of three primary components: one energy source, one active medium, and a group of 2 or more lasers.[2] A laser beam differs from a standard source of white light in various ways, like collimation, coherence (phase correlation), and monochromaticity (single wavelength).[3]

Light is often transmitted to the target tissue in dental laser systems via optical fibre cable, a hollow waveguide, or an articulated arm.[4] There are many of lasers available that can produce visible light, infra-red, and UV wavelengths. Lasers used in dentistry have wavelengths ranging from 488 nm to 10,600 nm. The principal lasers used in dentistry today are the argon, carbon dioxide (CO2), diode, neodymium-doped yttrium aluminium garnet (Nd: YAG), and erbium lasers, erbium-doped yttrium aluminium garnet (Er: YAG), and erbium, chromium: yttrium scandium gallium garnet (Er, Cr: YSGG).[5] The specific wavelength, output current, time of application, and total energy given to the tissue all influence the laser's effect on the tissues it's aimed at during a dental treatment.[6]

The most frequent dental operations are the excision of labial and lingual midline frenectomies, crown lengthening procedures, curing composites, and the management of gingivitis. Caries identification and elimination, bleeding problems, pain relief and hypersensitivity treatments. Gingivectomy, gingivoplasty, soft-tissue defects, and other procedure, every type of aphthous ulcers can be adequately treated by using lasers for dentistry.[7]

HISTORY

Gordon Gould was the first to introduce the LASER in 1957, based on Albert Einstein's light propagation theory and stimulated emission idea. In 1960, Theodore Maiman employed laser for the first time at Hughes Aircraft Company, USA, utilising a Ruby lasing medium to generate light with a high energy density. In the same year, Kumar Patel pioneered the use of CO2 LASER. Leon Goldman was the first to demonstrate the clinical use of LASER on dental tissues in 1969. Paghidiwala first described the use of Er: YAG in year 1985, and then employed it for hard tissue in the year 1997 and on the soft tissue the following year.[8]

DENTAL LASERS

1.ARGON LASERS: This laser, which uses gas as its active medium, emits light at 488 nm and 512 nm wavelengths. Blue light at 488 nm is often utilised to start the polymerization of restorative composite materials. The 514 nm blue-green light is absorbed most in tissue.[4] This laser is frequently used in gingival surgery for haemorrhage management, in addition for identifying fissures and deterioration of tooth using the transillumination technique.[9]

2.CO_2 LASERS: CO2 gas is the laser's active medium. It emits light with a wavelength of 10,600 nm that is invisible to the naked eye. When compared to other dental laser systems, CO2 laser wavelength has high absorption in H_2O and the maximum absorption in hydroxyapatite.[4] This laser has some benefits, consisting of quick removal of tissues, excellent haemostasis and a shallow penetration depth, that is why it is often employed for surgery on delicate tissues. When employing a CO2 laser, however, the tooth structure surrounding the soft tissue surgical site must be properly preserved. The use of these lasers on hard tissue is not recommended.[6]

3.Nd: YAG LASERS: The first dental laser system used a Nd: YAG active medium, which is a YAG crystal doped with neodymium.[10]. Because of the dense coagulation layer, the Nd: YAG achieves long-term haemostasis. It is utilised for removing delicate tissue in addition to surgical uses, and researchers have investigated its usage for nonsurgical sulcular debridement.[11] This type of lasers are exclusively absorbed by soft tissues, it is safely employed for performing surgery on the soft tissues around the teeth.[2]

4.DIODE LASERS: The emission source in the diode laser is a semiconductor. Examples of semiconductor lasers are gallium aluminium arsenide (GaAlAs) and helium neon (HeNe). The GaAlAs active medium is solid and made up of gallium, arsenide, and aluminium. Diode laser used in dentistry have wavelength between 800nm to 980nm. In spite of the rapid absorption of light in this spectrum by pigmented tissues and its deep penetration into soft tissues, dental hard tissues and water are poorly absorbed.[4] It's also safe to use for soft tissue procedures like gingival recontouring, crown lengthening, and hypertrophic tissue ablation.[2]

5.ERBIUM LASER: For dental purposes, erbium lasers are most typically utilized. Erbium lasers used in dentistry are ‘Er:YAG’ and ‘Er: Cr: YSGG’ lasers. [4,12] The active medium of the Er: YAG laser with the wavelength 2,940 nm is YAG, whereas the Er, Cr: YSGG laser with the wavelength of 2,790 nm is solid yttrium, scandium, and garnet.[4] These wavelengths have the largest hydroxyapatite absorbance of any dental laser, as well as the highest water absorbance. Erbium lasers can be used to remove hard tissue since both bone and teeth contain large amounts of hydroxyapatite and water.[12]

There are four types of interactions that can occur:[13]

1.ABSORPTION: Photons are elementary particles that are absorbed by certain molecules called chromophores. The beginnings of light energy are transformed into different energy types.

2.REFLECTION: Without interfering with or penetrating the surface, the laser beam bounces off it.

3.TRANSMISSION: Initially, energy passes through the surface tissues before it interacts with the deeper tissues. It can be viewed using diode and Nd: YAG lasers.

4.SCATTERING: The energy emitted spreads in all directions as it hits the tissue. They are unappealing and have no clinical utility.

BIOLOGICAL EFFECTS OF LASER

Laser has a total of five distinct effects.:[13]

1.THE PHOTOTHERMAL EFFECT: When the light energy strikes a tissue of interest, it is converted to heat, causing the cells to vaporise. When chromophores receive laser energy and release heat as a result, this phenomenon is produced. Work like incising tissue or coagulating blood is done with this heat. When CO2 laser is utilised on teeth, photothermal ablation is at work as hard tissue is vaporised during removal, whereas photothermal interaction is predominant in soft tissue treatments. Because these operations generate heat, more caution is essential to minimise thermal harm to the target tissues.

2.FLOURESCENCE: When a visible wavelength 655nm is used on a carious tooth during diagnostic operations, this event may occur. The degree of fluorescence is proportional to the lesion's size.

3.PHOTODISRUPTIVE EFFECTS: Short pulsed bursts of extremely high intensity laser light contact water molecules in the tissue, causing the water molecule to expand thermally. This generates a thermomechanical sonic shock capable of effectively shattering tooth and bone. Because of this kind of shock waves a unique popping sound was detected during Erbium LASER operation. Thermal injury is extremely improbable when there is no remnant heat.

4.PHOTOCHEMICAL: A chemical reaction occurs within the tissue as a result of the photon produced.

5.PHOTOBIOMODULATION: It is LASER's capacity to accelerate healing, improve circulation, and lessen discomfort. Biostimulation causes histological changes such as enhanced collagen production, fibroblast proliferation, and osteogenesis. The majority of these reactions are caused by LASER's interactions with the mitochondria and cellular matrix. In dentistry, biostimulation (Low Level Laser therapy) is used to alleviate postoperative pain.

EFFECTS ON ENAMEL, DENTINE AND PULP [13]: Protein denaturation at 45-60 degrees, necrosis and coagulation at temperatures above 60 degrees, and vaporisation of water in tissue (temperatures more than 100 degrees) are some of the effects of LASER on tissues.

ENAMEL: Microcracks emerge as a result of the water vaporising process.

DENTINE: Although there are no visible fissures, the damage is primarily necrosis and carbonisation.

PULP: Rise of a few degrees creates irreparable pulpitis, but a rise of one degree causes pulp necrosis.

ADVANTAGES: Lasers are light, handy and most of the time wireless. They are easy blood-free environment.[13].

DISADVANTAGES: LASER has a few drawbacks, including a higher cost, less tactile sense as compared to traditional procedures, and the need for the specialist training to use it.[13]

LASER IN CLINICAL APPLICATIONS:

1.Laser Etching: When laser energy is applied to enamel, it induces localised ablation and melting, and hence loss of enamel structure.[14] Enamel removal (etching) is mostly caused by micro explosions. There may also be a buildup of entrapped water in the enamel. Some hydroxyl-apatite crystals have melted. Temperature induced alterations on the enamel are caused by laser irradiation in particular. Based on the laser and the amount of energy delivered to the surface. Surfaces are roughened and irregularities are generated to a depth of 10–20 nm as if acid etching had been performed. [15] If 0.60kg/mm bond strength is considered the minimum acceptable value for clinical application, the study's findings imply that to achieve consistent surface conditioning, laser enamel etching should be conducted at the complete power output of the ‘American Dental Nd: YAG laser’.[16]

2. De-bonding technique with a laser: With promising results, lasers are employed in enamel acid etching and bracket de-bonding. This method has been demonstrated to be effective in order to de-bond, leading to a lower adhesive residual relatively and index minor increase in pulp temperature. The use CO2 and Nd: YAG lasers, in particular, has yielded satisfactory results with minimal side effects from increased pulp temperature.[16] Strob et al. [17] investigated the effectiveness of ‘CO2 and Nd: YAG’ lasers in removing ceramic brackets from the enamel surface. When compared to traditional debonding approaches, laser assisted debonding was found to significantly minimise residual debonding force, the danger of enamel damage, and the rate of failure. As a result, this approach has the capability of being less stressful (less unpleasant) and more secure for the patient (reduced danger of enamel damage).s

3. Lasers for light curing: Light-cured adhesives provide a longer installation time, allowing for more precise bracket positioning. Curing light takes 20-40 seconds to set each brackets which is the main drawback of this technique. Although light-cured adhesives have the same shear bond strength as chemically activated adhesives, the bond strength improves significantly between five min and 24 hours of application, with the bond strength at 5 minutes being only 60 to 70 percent of the strength properties at 24 hours. The capacity of an argon laser to accomplish photopolymerization of composite resins has been the subject of recent research. To commence polymerization, dental resins with photo-activation employ a reducing agent, like a tertiary amine, and a dike tone initiator, camphoroquinone. With a peak of activity centred at 480 nm, this system of photoinitiators is extremely light sensitive in the visible spectrum's blue region. The argon laser is monochrome and emits the light in a wavelength of 457.9–514.5 nm in the blue and green spectra, making it ideal for polymerisation of composites.[16] Talbot et al. [18] investigated if irradiation of enamel with an argon laser can be utilised to bind orthodontic brackets and found that argon lasers can achieve bonding power comparable to those achieved with traditional resins with a light cure

4. Using lasers to regulate orthodontic treatment and improve aesthetics: Patients seeking orthodontic treatment are looking for more than simply "straight teeth." They value properly-aligned, white teeth, functional and occlusal stability, gingival aesthetics, well-proportioned features as well as stunning grins. In addition, patients want this to be completed in a reasonable length of time. The soft-tissue laser, recently acquired popularity as an effective tool for managing treatment and improving aesthetic results.[16]

5. Pain relief: Irfan Qamruddin et al. [19] tested the effect of a single dose of low-level laser therapy on elastomeric separator-induced pain in a single-blind trial. The LASER used in the investigation was a GaAlAs Diode LASER operating at 200 mW in constant mode with a wavelength of 940 nm. They came to the conclusion that the laser provide effective pain relieved by improving blood circulation, which eliminates pain mediators and boosts cellular activity (BioStimulation).

6.Accelerating orthodontic tooth movement: Following LLLT, there was an increase in tooth mobility, which is related to an increase in collagen of synthesis, new capillaries formation, formation of bone. The release of interleukin 1 beta is enhanced, and the activity is more pronounced in the maxilla than other parts of the jaw. The laser used had a wavelength between 600–1000 nm and was made of GaAlAs and HeNe. For 80s for 2 days, the laser was used on the buccal as well as palatal aspects. For 5 seconds, the laser was positioned on the neck of tooth on the labial and lingual side. The retraction was examined after 4 weeks and 8 weeks and at the end of retraction. [20]

7. Use of Lasers on Soft Tissue in Orthodontic Treatment: Recontouring of the gingiva, unerupted teeth are exposed., enlarged tissues and inflammatory tissue removal, frenectomies, and aphthous lesions therapy are some of the applications for soft tissue connected to orthodontic intervention. [21 Lasers are employed for contouring of gingiva for improving smile, teeth proportioning before the bracket implantation, crown elongation and crown asymmetry treatment, interdental and gingival margin contouring. [22] Soft-tissue procedures, including dental frenectomies, papillectomies, and gingival incisions, are commonly performed with Nd: YAG lasers.[2]

LASERS IN NON-CLINICAL APPLICATION:

1.Laser scanning: The laser only offers the surface map and cannot provide colour information for the texture map, the procedure for scanning needs the individual to remain motionless for a period ranging from seconds to minutes or longer as the scanner spins around the head of the patient. This information is provided via a laser scanner-registered colour camera. Orthodontic equipment for example splints, computerised wire bending, e-models, and surgical simulation models can be made by utilising three-dimensional digital data from a laser scanner using computer-aided manufacturing and stereolithography processes. The software can be used to combine photos obtained from various angles, removing undercuts. 3D computer-aided wire-frame schematics enable models to be cut, overlaid, and computed measurements, making studies using tooth casts a breeze.[16]

2.Laser welding: Individual orthodontic appliances and efficient treatment processes typically necessitate metal framework connections. Laser welding is a new technology for combining metal frameworks. To emit laser beams, YAG crystals with additional neodymium are primarily used. Laser welding has several advantages, including the absence of solder, which prevents corrosion at the junction, a tiny focus, and an argon shielding gas, which prevents oxidation around the welding zone [16]

LASER SAFETY

According to the ANSI and the Occupational Safety and Health Administration, lasers are divided into 4 categories as per their possibility for harm: [23]

Class I: This class consist of laser which have low-power that are safe to view.

Class II a: This class consist of visible lasers with a low power output. If one looks into the beam for more than 1s, chances of damage are there.

Class II: This class consist of visible lasers with a low output power. When viewed along the beam for more than 0.25 seconds, they become harmful.

Class IIIa: This class of lasers when viewed for less than 0.25 seconds, it consists of medium-powered lasers that are not harmful.

Class III b: When these lasers are seen directly within the rays for any period of duration, that are hazardous.

Class IV: High-powered lasers can harm the skin and other organs like eyes. The beams that are reflected are also harmful. Appropriate safety precautions must be used. This category includes the majority of lasers used in medicine and dentistry.

The following are the various sorts of dangers that may be faced in the clinical practise of dentistry:[16]

- Dangerous to the eyes
- Tissue harm
- Risks to the respiratory system
- Explosions and fire
- Electrocution
- Dangers related to combustion
- Dangers related to equipment

CONCLUSION:

Laser means light amplification emission of radiation. LASER applications include pain reduction, an alternative to etched and bond procedures, increased in movement of tooth, removal of brackets, bracket number, increasing implant fixation, bracket design, a decreased in demineralization process, and surgery of oral tissue. Along with merits there are few demerits like lasers are costly for patients, costly for the dental practitioner, sometimes it increases the length of treatment and destructive for tissues.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

References:

1. Pick RM. Using lasers in clinical dental practice. J Am Dent Assoc 1993;124:37-4
2. Nalcaci R, Cokakoglu S. Lasers in orthodontics. Eur J Dent 2013;7:119-25.
3. Maiman TH. Stimulated optical radiation by ruby. Nature 1960;187:493-4
4. Coluzzi DJ. Fundamentals of dental lasers: Science and instruments. Dent Clin North Am 2004;48:751-70
5. Harris DM, Pick RM. Laser physics. In: Miserendino LJ, Pick RM, editors. Lasers in Dentistry. Singapore: Quintessence Publishing Co, Inc.; 1995. p. 27-38.
6. Lomke MA. Clinical applications of dental lasers. Gen Dent 2009;57:47-59.
7. Miserendino LJ, Pick RM. Current applications of lasers in dentistry. In: Lasers in Dentistry. Singapore: Quintessence Publishing Co, Inc.; 1995. p. 126-8
8. KUMAR, Dr, et al. "LASERS IN ORTHODONTICS–A REVIEW." *European Journal of Molecular & Clinical Medicine* 7.4 (2020): 1669-1674
9. Moritz A. Cavity preparation. In: Moritz A, editor. Oral Laser Application. Berlin: Quintessenz; 2006. p. 75-136

10. GoldsteinA, White JM, Pick RM. Clinical applications of the Nd: YAG lasers. In: Miserendino LJ, Pick RM, editors. Lasers in Dentistry. Singapore: Quintessence Publishing Co. Inc.; 1995. p. 199-217

11.Fornaini C, Rocca JP, Bertrand MF, Merigo E, Nammour S, Vescovi P. Nd: YAG and diode laser in the surgical management of soft tissues related to orthodontic treatment. Photomed Laser Surg 2007;25:381-92.

12. van As G. Erbium lasers in dentistry. Dent Clin North Am 2004;48:1017-59, viii.

13. KUMAR, Dr, et al. "LASERS IN ORTHODONTICS–A REVIEW." *European Journal of Molecular & Clinical Medicine* 7.4 (2020): 1669-1674.

14. Brantley WA, Eliades T. Orthodontic Materials. Stuttgart: Th ieme; 2001

15. von Fraunhofer JA, Allen DJ, Orbell GM. Laser etching of enamel for direct bonding. Angle Orthod 1993;63:73-6.

16. Arjun Karra, Mohammadi Begum, "Lasers in orthodontics," Int J Contemp Dent Med Rev, vol. 2014, Article ID 041014, 2014. doi: 10.15713/ins.ijcdmr.

17. Strobl K, Bahns TL, Willham L, Bishara SE, Stwalley WC. Laseraided debonding of orthodontic ceramic brackets. Am J Orthod Dentofacial Orthop 1992;101:152-8

18. Talbot TQ, Blankenau RJ, Zobitz ME, Weaver AL, Lohse CM, Rebellato J. Eff ect of argon laser irradiation on shear bond strength of orthodontic brackets: An in vitro study. Am J Orthod Dentofacial Orthop 2000;118:274-9.

19. PAIN REDUCTION AFTER ELASTOMERIC SEPARATOR PLACEMENT : Qamruddin, I., Alam, M. K., Fida, M., & Khan, A. G. (2016). Effect of a single dose of low-level laser therapy on spontaneous and chewing pain caused by elastomeric separators. American Journal of Orthodontics and Dentofacial Orthopedics, 149(1), 62–66. doi:10.1016/j.ajodo.2015.06.024

20.] LLLT FOR ACCELERATED ORTHODONTIC TOTH MOVEMENT : Guram G, Reddy RK, Dharamsi AM, Ismail PM, Mishra S, Prakashkumar MD. Evaluation of low-level laser therapy on orthodontic tooth movement: a randomized control study. Contemporary clinical dentistry. 2018 Jan;9(1):105.

21. Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics: Part 3. Laser treatments for tooth eruption and soft tissue problems. Am J Orthod Dentofacial Orthop 2005;127:262-4.

22. Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics: Part 2. Soft tissue lasertechnology and cosmetic gingival contouring. Am J Orthod Dentofacial Orthop 2005;127:85-90.

23. Miserendino LJ, PickRM, BlankenauRJ. Laser safety in dental practice. In: Miserendino LJ, Pick RM, editors. Lasers in Dentistry. Singapore: Quintessence Publishing Co, Inc.; 1995. p. 85-103.

24 Chaudhari, P.S., Chandak, M.G., Relan, K.N., Chandak, P.G., Rathi, C.H., Chandak, M.S., Dass, A., 2021. Lasers in Diagnosis, Interception and Management of White Spot Lesions and Dental Caries - A Review. JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS 10, 624–631. https://doi.org/10.14260/jemds/2021/134

25. Singh, A.L., Chandak, M., Ghatge, A., Chandak, S., 2021. Study of Efficacy of Diode Laser in Unwanted Facial Hair: Dynamic Versus Static Mode. JOURNAL OF PHARMACEUTICAL RESEARCH INTERNATIONAL 33, 267–272. https://doi.org/10.9734/JPRI/2021/v33i40B32286

26. Mukherji, R., Sune, P., 2020. Contrast Sensitivity and Visual Acuity Before and After Nd:YAG Capsulotomy in Patients with Posterior Capsular Opacification: A Prospective Study. JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH 14. https://doi.org/10.7860/JCDR/2020/43120.13590

27. Gilani, R., Bajaj, P., Mankar, N., Vishnani, R., Daigavane, P., Niranjane, P., 2020. Photo Catalytic Silver Modified Orthodontic Brackets - An Innovative Method for Prevention of White Spot Lesions. JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS 9, 2787–2790. https://doi.org/10.14260/jemds/2020/607

28.John, Z.A.S., Shrivastav, S.S., Kamble, R., Jaiswal, E., Dhande, R., 2020. Three-dimensional comparative evaluation of articular disc position and other temporomandibular joint morphology in Class II horizontal and vertical cases with Class I malocclusion: A magnetic resonance imaging study. ANGLE ORTHODONTIST 90, 707–714. https://doi.org/10.2319/121519-801.1