Review Article

The extended tentacles of laser - From diagnosis to treatment in orthodontics: An overview

S. D. Milling Tania, Cynthia Sathiasekar[1], Job Jacob Anison[2], B. V. Samyukta Reddy[3]

Departments of Orthodontics and [1]Oral Pathology, Rajas Dental College and Hospital, Tirunelveli, [2]Department of Orthodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, [3]Department of Oral Pathology, Dr. Sudha and Nageswara Rao Siddartha Institute of Dental Science, Vijayawada, Andhra Pradesh, India

Address for correspondence:
Dr. S. D. Milling Tania,
E-mail: taniadhas@yahoo.com

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ABSTRACT

Since the introduction of lasers in dentistry in the mid-1990's, research in laser supported dental therapies is progressing at a rapid pace. Orthodontics is no exception. In orthodontics, lasers have many diagnostic, therapeutic, and biomodulating applications. To update the various applications of lasers in orthodontics. Lasers work by delivering energy in the form of light. Laser, striking the biological tissues can either get reflected, absorbed or scattered depending on several factors. Depending on the fate of the emitted laser, it can be applied for different diagnostic, therapeutic and surgical procedures. The knowledge and understanding of different types of lasers and its specific applications is a prerequisite before it can be applied beneficially. In Orthodontics, the versatility of laser has expanded into bonding, curing, debonding, imaging, growth modification, pain reduction, etc. Definitely laser has extended its tentacles from diagnosis to treatment in orthodontics.

KEY WORDS: Biomodulation, laser, lasers in orthodontics

The unique properties of light amplification by stimulated emission of radiation have made it widely applicable in various areas of medicine and dentistry. Since the genesis of this unique optical device, it has undergone tremendous improvements and taken new shapes in different branches of dentistry. Orthodontics is no exception. Laser, striking the biological tissues can get reflected, absorbed or scattered based on various parameters. Depending on the fate of the emitted laser, it can be applied for different purposes. The knowledge and understanding of these different types of lasers and its specific applications is a prerequisite before it can be applied beneficially. In Orthodontics, the laser has extended its tentacles into bonding, curing, debonding, imaging, growth modification, pain reduction, etc., This article attempts, to summarize, the various applications of lasers in orthodontics along with notes on its advantages and disadvantages.

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Versatility of Laser - From Diagnosis to Treatment

Diagnostic applications

- Laser scanning-diagnostic lasers
- Holography, interferometry

- Digital models
- Detection of caries.

Therapeutic applications: Bonding to debonding

- Laser etching
- Bonding to porcelain
- Laser adhesive curing
- Debonding.

Biomodulation effects of laser

- Orthodontic tooth movement
- Growth modification
- Pain reduction
- Retention and relapse.

Miscellaneous

Laser welding.

Diagnostic Applications

Diagnostic lasers

The paradigm shift from hard tissue emphasis to soft tissue emphasis in diagnosis and treatment planning has made three-dimensional (3D) analysis of soft tissues using laser scanning more important in orthodontics. The 3D laser scanning in addition to its application in diagnosis also assesses growth-related changes[1] and clinical outcomes after orthognathic surgery.[2,3]

Mode of action

Laser scanning is based on the concept of the stereoscopic method of imaging.[4] Two pairs of stereo cameras when placed at a distance use the principle of triangulation to image completely the curved facial surfaces.

Advantages

- Ease of use
- Self-calibration
- Auto image distortion correction
- Cost
- Speed
- Portability
- Noninvasiveness.

Applications

- Studying facial soft tissue changes with growth, soft tissue changes after orthognathic surgery, functional facial muscle movements
- Three-dimensional computerized data from a laser scanner can be transformed by using computer-aided manufacturing and stereolithography techniques to produce orthodontic appliances such as splints, computerized wire bending, e-models, and surgical simulation models
- Studies involving dental casts can be performed with ease because computerized 3D wire-frame diagrams allow models to be cut, superimposed, and measured in the computer[5]
- Digital models: Computer-based digital models eliminate the requirement for production and storage of casts and allow the assessment of tooth size, arch form, and tooth-arch discrepancies reliably
- Studies involving craniofacial anomalies, cleft lip repair, asymmetrical facial growth, and nasal molding procedures are done with laser scanning.

Laser Doppler flowmetry

Laser Doppler flowmetry (LDF) finds its application in assessing the vitality of the tooth during or prior to undergoing orthodontic treatment.[6] It is a noninvasive electro-optical technique, which measures the velocity of red cells.

Mode of action

Light emitted from the laser beam is scattered by the moving red cells within the pulp, and the scattered light undergoes a frequency shift. The frequency shift is detected and processed to produce a signal that is a function of red cell influx thereby reflecting the vascular response.

Advantages

- Noninvasive
- Valid as they reflect vascular rather than nervous responsiveness.

Application

- Pulpal responses to orthodontic forces or orthopedic forces created by rapid maxillary expansion (RME) can be accurately assessed with LDF
- Also finds application in assessing the blood flow measurements after orthognathic surgery.

Laser florescence for caries detection

Laser florescence allow the early detection and quantification of initial caries formed around orthodontic brackets minimizing the damage of caries lesions in orthodontic patients.[7]

Mode of action

This method is based on the emission of light from a diode laser and measurement of fluorescence emitted from carious lesions. The fluorescence is believed to originate from protoporphyrin and related metabolic products of oral bacteria.[8]

Advantages

- It is a quantitative method used in assessing the severity, progression, depth of white spot lesions during orthodontic treatment[9]
- Reproducible
- Good performance.

Therapeutic Lasers

Enamel conditioning for bracket bonding

Laser etching of enamel creates micro cracks that are ideal for resin penetration. The surface produced by laser irradiation becomes acid resistant thereby reducing the caries susceptibility.

Mode of action

Laser irradiation causes thermally induced changes on the enamel surface. It causes surface roughening and irregularity similar to that of acid etching. The etching is through a process of continuous vaporization and microexplosions resulting from vaporization of water trapped in the hydroxyapatite matrix.[10]

Advantages

- Water spraying and air drying are not needed with laser etching
- Time can be saved. Saving chair time also improves adhesion because it reduces the risk of salivary contamination
- Laser etching is painless and does not involve either vibration or heat
- Easy handling of the apparatus
- Laser radiation of dental hard tissues modifies the ratio of calcium-to-phosphorus, also reduces the carbonate-phosphate ratio, water and organic component contents, leading to the formation of more stable and acid resistant compound, thus reducing susceptibility to acid attack and caries.[11,12] Laser etching is also reported to create remineralization of micro spaces that trap free ions and thus making it more acid resistant.[13]

But contradicting findings exist about the use of lasers for enamel etching in terms of the bond strength.

Curing of resin

The argon lasers used for polymerization can polymerize a light-cured orthodontic adhesive four times faster with less frequency of enamel fracture and debonding than with the conventional curing light.

Mode of action

The light from argon laser is within a narrow range around 480 nm matching well with the absorption peak of the photoinitiator, camphoroquinone in light-curing adhesive materials thereby initiating the polymerization.

Advantages

- It is claimed that the polymerization is four times faster than with conventional visible light
- Argon laser beam is collimated, directing on a specific target, resulting in a greater power density than the conventional halogen light
- Less frequency of enamel fracture and debonding than with the conventional curing light
- The pulp chamber temperature increase from the laser units was significantly lower than those of the conventional curing light
- The bond strength for argon laser curing is comparable to conventional light curing and is sufficient for clinical applications.

Disadvantage

The expense of this laser has prevented it from becoming a popular light-curing source. This disadvantage is overcome with the introduction of diode pumped solid state laser which is compact and much cheaper than the argon laser.

Bonding to porcelain

Laser etching is an acceptable substitute for hydrofluoric acid (HF) in conditioning the porcelain for bonding and avoids the risk of gingival burns associated with the use of the latter.[14]

Advantages

- Laser eliminates the need to roughen the porcelain prior to bonding. Additionally, it also eliminates the gingival burns with the use of HF and the need to repolish the porcelain at deband.

Furthermore, etching time is considerably shorter with laser compared to HF.

Prevention of white spot lesions

Prevention of white spot lesion has become a major concern for the orthodontists. Laser irradiation renders the enamel surface resistant to acid thereby reducing the occurrence of white spot lesions.

Mode of action

Laser irradiation of the enamel modifies the calcium-phosphate ratio leading to the formation of more stable and less acid-soluble compounds, thus reducing the susceptibility to caries attack. The enamel surface is sealed by laser and is less permeable for the subsequent diffusion of ions into and from enamel. Laser treatment also reduces the threshold pH at which dissolution occurs.

Bracket debonding

The use of lasers in debonding eliminates problems such as enamel tear outs, bracket failures, and pain that are encountered

during conventional ceramic bracket removal techniques. Additionally, lasers have the advantage of decreasing debonding force and operation time.

Mechanism of action

Laser energy degrades the adhesive resin by three methods.

Thermal softening, thermal ablation, and photoablation.[15] Thermal softening occurs when the laser heats the bonding agent until it softens. This causes the bracket to sag and slide off from the tooth surface.

Advantages

- Eliminates enamel tear outs, bracket failures, and pain during debonding
- Reduced operation time
- Reduced intrapulpal temperature rise.

Therapeutic Applications

Laser minor surgery

Laser finds its application in orthodontics in gingival enlargements, gingival hyperplasia and reshaping gingival shape and contours, fibrotomy, frenectomy.

Mechanism of action

Lasers cut by thermal ablation-decomposition of tissue through an instantaneous process of absorption, melting, and vaporization. Essentially, the cells of the target tissue absorb the concentrated light energy, rapidly rise in temperature, and produce a micro-explosion known as spallation.[16] Laser surgery offers numerous advantages compared with traditional scalpel surgery.

Advantages

- Soft tissue excision is more precise with a laser than a scalpel[17]
- Laser coagulates blood vessels, seals lymphatic and sterilizes the wound during ablation, maintaining a clear and clean surgical field[18]
- Laser sterilizes as it cuts, reducing the risk of blood-borne transmission of disease
- Shorter operative time and faster postoperative recuperation
- Laser surgery is routinely performed by using only topical anesthetic, which is beneficial in an orthodontic clinic[19]
- There is less bleeding, minimal swelling, and it does not require the need for irritating sutures or unsightly periodontal dressing[20]
- Less damage occurs to adjacent tissues
- Postsurgically, patients, report less discomfort and fewer functional complications and require fewer analgesics than do patients treated with conventional scalpel surgery[20]
- Less wound contraction occurs during mucosal healing. Thus, scars do not develop.[21]

Disadvantage

- High expense
- Some clinicians have reported greater tactile sense with a scalpel
- Tissue desiccation and poor wound healing have also been reported in few cases.[22]

Biomodulating effect of lasers

Low-level laser (LLL) therapy could be recommended for pain control during fixed orthodontic appliance therapy.

Mode of action

The potential mechanisms involved in pain relief[23] have been postulated as:

- Direct action on nerve: Laser can inhibit the activity of sodium-potassium adenosine triphosphate (ATP)-ase responsible for never depolarization in the generation of the action potential.[24] This effect is likely to be maximal for the small diameter C fibers responsible for most chronic pain, due to their lack of a protective myelin sheath
- Energization of inactivated enzymes: There is evidence that the laser energy can reactivate the enzymes, which are normally inactivated in areas of chronic inflammation. This activated enzymes can further breakdown the free radicals, the source of pain
- Production of energy molecules (ATP) in dysfunctional muscle
- The laser light causes the production of ATP in the presence of which the interaction of myosin and actin occurs.[25] The lack of this may contribute to painful dysfunction
- Reduction of prostaglandin levels. Evidence from the clinical and cell culture work say that laser exposure can reduce levels of the algogenic substance prostaglandins2.[26]

Growth modification

Low-level laser therapy has been used in the growth modification procedure. Studies on rats have shown the increase of mandibular length with LLL therapy. Studies have also found that LLL accelerates the process of bone regeneration during the consolidation phase after distraction osteogenesis.[27] The LLL, associated with RME, provided efficient opening of the midpalatal suture and influenced the bone regeneration process of the suture, accelerating healing.[28]

Mode of action

It is hypothesized that LLL therapy stimulates the mandibular growth through an increase in vascular endothelial growth factor (VEGF) and Runx2 in bone healing since these have been shown to be correlated with increased mandibular growth. Runx 2 is involved in chondrocyte differentiation, whereas VEGF and collagen type X are involved in endochondral ossification.

Influence of low-level laser therapy on orthodontic tooth movement

Low-level laser therapy has been found to increase the rate of tooth movement during orthodontic treatment.

Mode of action

- Laser therapy causes the increase of receptor activator of nuclear factor kappa-B ligand in periodontal ligament thereby increasing the rate of tooth movement during orthodontic treatment[29]
- Low level laser therapy can increase macrophage-colony stimulating factor on the compressed side and may also increase osteoclastogenesis leading to tooth movement[30]
- Additionally, LLL therapy increases osteoblastic cell proliferation and can therefore stimulate osteogenesis and increase bone density on the traction side.[31]

Retention and Relapse

Effects of low-intensity laser therapy (LILT) on periodontal tissue remodeling during relapse and retention of orthodontically moved teeth have been documented. LILT when combined with a retainer on the moved teeth may shorten the retention period by accelerating periodontal remodeling in the new tooth position, whereas, LILT on the moved teeth left without any retainer would rather increase the rate of relapse after treatment.[32]

Miscellaneous Applications: Laser Welding

Laser welding is a preferred method for effective joining of components made of pure titanium because it preserves the biocompatibility potential of titanium preventing the risk of galvanic corrosion. Heating is mainly focused at the point of application; therefore the surrounding areas do not damage.[33]

Laser welding is recently used in bracket manufacturing as an alternative to brazing. Additionally, the force and torque applied for tooth movement can be controlled by welding different sizes, shapes, and types of orthodontic wires.

Advantages

- Fewer heat effects on the surrounding area to be welded
- No materials (such as investment materials, furnace, and gas torch) are necessary for conventional dental soldering
- Reduces the risk of corrosion
- Acceptable mechanical performance in association with a low risk of joint failure.

Discussion

Research in laser supported therapies in Dental Sciences is progressing at a rapid pace. The proper knowledge of the fundamentals and principals of the laser facilitates its utilization appropriately in the areas needed. The advantages, cost factor, and disadvantages should be weighed when applying a laser for a particular application. The variable composition of human tissue and the differing ways in which laser energies are absorbed demands a specific type of laser for each dental application. Though lasers are relatively simple to use, precise with several advantages, certain precautions need to be taken to ensure a safe and effective operation. Laser safety is regulated according to American National Standard Institute. The lasers used in medical and dental purposes are high powered lasers that can cause damage to the skin and eyes. So it is necessary to take appropriate safety measure. Precautions in the form of wearing wavelength specific protective eyewear are mandatory in performing laser procedures. Additionally, limiting access to the surgical environment, minimizing reflective surfaces, also can prevent the possible damage from the laser.

Everyone who wants to conduct conscientious dentistry in the future inevitably has to integrate the advantages of laser substitution into his or her therapeutic strategy.

Conclusion

Since the introduction of lasers to the dental profession, it has widely stretched its tentacles in every branch of dentistry. Orthodontics is no exception. Definitely laser has extended its tentacles from diagnosis to treatment in orthodontics. In modern times, with the availability of more advanced laser devices at a relatively lower cost, laser treatment can be adopted at various stages of orthodontic treatment.

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