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Lasers- A contemporary tool in orthodontics

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Abstract:
Lasers have got extensive application not only in the field of medicine but also have broaden its horizon in dentistry. Orthodontics dating back to the time of Egyptian mummies to the recent advances had travelled through many appliances, mechanics and innovations to reach the greater heights in dentistry. We orthodontists are familiar with the term LASER (Light Amplification by Stimulated Emission of Radiation) however its application in the field is yet to be explored. Recently the laser has gained attention as an effective tool to manage orthodontic treatment and enhance our esthetic out comes with greater results.
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Introduction:
The word laser is an acronym derived from the phrase “light amplification by stimulated emission of radiation.” A laser-equipped device can generate a high-intensity light that is monochromatic, unidirectional, and parallel. These unique characteristics make the laser useful for commercial and medical applications. An understanding of the general properties of lasers allows the physician and layperson to better appreciate the technology and its capabilities and limitations.

History:
The theoretic principles behind the laser were developed as early as 1917, when Einstein laid the groundwork for stimulated emission in his treatise "On the Quantum Theory of Radiation."[1] The ruby laser became the first medical laser when it was used in

1963 to coagulate retinal lesions. The first gas laser, which was also developed in 1961, used a mixture of helium and neon. Although its beam was not powerful enough to trigger a thermal reaction, its red color allowed it to be used as an aiming beam for invisible lasers such as the carbon dioxide (CO_2) laser. Currently, it is marketed in Europe and Asia as a biostimulator to relieve pain and accelerate wound healing.

In 1961, a laser generated from crystals of yttrium-aluminum-garnet treated with 1-3% neodymium (Nd:YAG) was developed. Today, the Nd:YAG laser is mainly used to ablate tattoos and tumors of the genitourinary and gastrointestinal tracts, although it has many other uses, including ophthalmic surgery (e.g., peripheral iridectomies/iridotomies, postcataract capsulotomies) and hair removal.

In 1962, the argon laser was developed. The argon laser is used to photocoagulate (i.e., thermally obliterate without vaporization) blood vessels in the treatment of diabetic retinopathy and port-wine stains. In 1964, Patel at Bell Laboratories developed the CO_2 laser. The energy generated by this laser can be used for cutting or volume ablation by means of tissue vaporization. This unique characteristic makes the CO_2 laser the most widely used medical laser today.

Basic types of lasers:

Three types of lasers are available for use in dentistry: the CO2 laser, the erbium laser, and the diode laser. The CO2 laser does not contact the tissue during the cutting phase; thus there is no tactile feedback during the surgical incision. It operates with a wavelength that is invisible to the eye, so the fiber optic delivery system has a helium-neon (He-Ne) laser with a wavelength of 632 nm incorporated as an aiming beam. There is slight delay between when the incision is made and when it can be seen.

The erbium laser has a wavelength of 2790 to 2940 nm, which makes it ideal for absorption by both hydroxyapatite and water. It can also be used to cut soft tissue, but it does not control bleeding.

The diode laser has a wavelength of 812 to 980 nm, which is in the same range of the absorption coefficient of melanin. The laser energy is absorbed by pigmentation in the soft tissues, and this makes the diode laser an excellent hemostatic agent. Because it is used in contact mode, it also provides tactile feedback during the surgical procedure. The diode laser can often be used without anesthesia to perform very precise anterior soft tissue esthetic surgery or surgery in other areas of the mouth without bleeding or discomfort.[2]

Lasers in Dentistry

Lasers have a wide range of applications in various fields of dentistry, especially when conventional treatments are not effective. In endodontics, laser technology is being considered for dentin structure modification, cleaning and shaping of the root canal system, pulp diagnosis, and endodontic surgery. Lasers such as the Nd:YAG, CO_2, and semiconductor Diode lasers have been used in soft tissue treatment of the oral cavity. In periodontics, the Er:YAG laser has potential for clinical application in hard tissue treatment due to its ability to cut or contour bone with minimal damage and fast healing.[3]

In orthodontics too, lasers have been used in cosmetic gingival contouring; preparing and finishing anterior esthetic orthodontic outcomes ;in solving tooth eruption and soft tissue problems that impede efficient orthodontic finishing, laser surface scanning of craniofacial anomalies, laser fluorescence to detect demineralized areas of enamel, impactions etc.

Applications of lasers in orthodontics:

Esthetic contouring of the gingival scaffold within the smile framework

Important considerations in finishing our orthodontic patients in terms of smile esthetics now include concepts that are important in cosmetic dentistry—crown heights, tooth proportionality, and gingival shape and contours—therefore, the uses of soft tissue lasers in orthodontic practice broadly fall into the following categories: (1) improving gingival shape and contour, (2) lengthening crowns, (3) idealizing tooth proportionality, and (4) resolving crown/height asymmetries.[4]

Establishing tooth proportionality before bracket Placement

In smile design, our concepts of set formulas for bracket placement depend on the final incisor placement in the dynamic smile, determined by both the incisal edge and the gingival margin. It is therefore important to be able to visualize the crown in ideal proportion before bracket placement. The disproportion could be due to lack of incisor height (gingival encroachment or delayed or incomplete passive eruption requiring gingival reshaping) or incisors that are morphologically wider than ideal. To improve tooth proportion laser gingivectomy could be performed before bracket placement so that we could maximize our chances of positioning the incisors in their ideal vertical position. Because the soft tissue laser seals the incision as it is made, brackets can be placed immediately after the procedure, and healing of the tissue follows.[2]

Crown lengthening

Excellent application of crown lengthening is when a canine is substituted for a congenitally missing lateral incisor. When the first premolar is in the canine position, its crown height looks too short. An option is to lengthen the premolar crown by laser gingivectomy or simplified osseous crown lengthening.

Crown height asymmetry

If the smile line is asymmetric because of differential crown heights between the maxillary right central and lateral incisors, relative to the left side. Using the laser, excision of the gingiva on the right central and lateral incisors could be done, to make the smile more symmetric and greatly improved.

Contouring of gingival and interdental margins

Hypertrophic gingival margins are often seen in orthodontic treatment secondary to marginal gingival inflammation, both acute and chronic. The hypertrophic papillae could be ablated and the rolled gingival margins beveled to sharpen their contour adjacent to the crown of the tooth.

Four weeks after the procedure, the gingival margin greatly improved.

Soft tissue lasers are also used during minor surgical procedures like exposure of impacted teeth, frenectomy, operculectomy and atraumatic Implant placement procedures in orthodontics as (1) the laser cut is more precise than that of a scalpel, (2) the cut is more visible initially because the laser seals off blood vessels and lymphatics, leaving a clear dry field, (3) the laser sterilizes as it cuts, reducing the risk of blood-borne transmission of disease, (4) minimal postoperative pain and swelling have been reported, (5) less postoperative infection has been reported because the wound is sealed with a biological dressing, (6) less wound contraction occurs during mucosal healing, thus scars do not develop, and (7) less damage occurs to adjacent tissues.[5]

Laser etching of enamel for orthodontic bonding

Various commercially available laser systems have been introduced for dental use. Enamel and dentin surfaces etched with erbium, chromium-doped: yttrium scandium- gallium-garnet (Er,Cr:YSGG) lasers show microirregularities and no smear layer.[6] Laser etching inhibits caries, and this could be of great importance in orthodontics.[7] Because water spraying and air drying are not needed with laser etching, procedural errors can be reduced and time saved.[8] Therefore, Er,Cr:YSGG laser irradiation could be a suitable technique to etch enamel for orthodontic bonding.

Pain reduction in Orthodontics with the use of low level laser therapy

Pain from orthodontic treatment is mostly local and therefore may be controlled more efficiently by locally administered analgesic treatment. One suggested method to control pain is laser therapy.[9-13] Two types of laser have recently become available for dental applications. One type, which includes CO2 and Er:YAG lasers, is absorbed by only a thin surface layer of tissue. The other type penetrates into deeper tissue and includes Nd:YAG, He:Ne, and semiconductor lasers.

Several studies have reported analgesic effects of the tissue-penetrating Nd:YAG, He:Ne, and semiconductor lasers for reducing orthodontic pain. Local CO2 laser irradiation will reduce pain associated with orthodontic force application without interfering with tooth movement.

Three -dimensional laser scanning system

Our understanding of the growth of craniofacial features is improving with the development of accurate, low-cost, 3-dimensional (3D) imaging systems, which can be classified as destructive or nondestructive devices,[14] hard or soft tissue imaging devices,[15] and contact or noncontact devices.[16] The laser scanner can be used as a soft tissue scanner and is a valuable tool for its ease of application and creation of 3D images. Images have been created to establish databases for normative populations[17] and cross sectional growth changes,[18] and also to assess clinical outcomes in surgical [19-25] and nonsurgical treatments [26-28] in the head and neck regions.

Laser Fluorescence

Enamel demineralization with white spot formation on buccal surfaces of teeth is a relatively common side effect from orthodontic treatment with fixed appliances.[29-31] Treatment with fixed appliances makes conventional oral hygiene for plaque removal more difficult, thus increasing the cariogenic challenge on surfaces that normally show a low prevalence of dental caries.[32] White spot formation has been attributed to the effect of prolonged accumulation and retention of the bacterial plaque on enamel surfaces adjacent to the appliances. There is evidence, however, that suggests that such small areas of superficial enamel demineralization may remineralize.[33-34]

Sensitive methods that enable early detection and quantification of caries lesions make it possible to monitor changes in the enamel over time. Laser light induced fluorescence as a diagnostic method for detection of enamel caries at an early stage was introduced in 1982.[35]

When enamel demineralization takes place, minerals will be replaced mainly by water causing a decrease in the light path in the tooth substance. This will result in reduction of light absorption by enamel.[36] Because fluorescence is a result of absorption, the intensity of fluorescence will decrease in demineralized regions of the enamel, which appear darker than the sound tooth structure.[37-38] Studies have indicated that changes in mineral contents of enamel lesions may be accurately recorded with the laser fluorescence method.

Apthous ulcer management

For patients with apthous ulcer, the diode laser can be used in noncontact mode (1 to 2 mm away from the tissue) to irradiate the ulcer for approximately 30 seconds. The patient reports an immediate reduction of pain. The procedure creates a nonpainful laser wound that replaces the painful ulceration.

Recent researches of lasers used in craniofacial region

Apart from the above uses, the diode laser has also been tried in experimental animals for controlling the excessive growth of the mandibular condyle. It was found that a laser is effective in regulating facial growth and could be a substitute for current conventional methods such as a chin-cup.[39]

It was proposed earlier that orthodontic treatment might cause a decrease in blood flow to the pulp. [40] McDonald and Pitt Ford found that human pulpal blood flow was decreased when continuous light tipping forces were applied to a maxillary canine. [41] Understanding the effects of orthodontic force on the pulp is of particular importance, especially because altered pulpal respiration rate,[42]disruption of the odontoblastic layer,[43]pulpal obliteration by secondary dentin formation, root resorption,[44]and pulpal necrosis [45]have all been associated with orthodontic treatment. Nowadays, laser-doppler flowmetry is a commonly used method to determine the pulpal blood flow. Barwick and Ramsay evaluated the effect of a 4-minute application of intrusive orthodontic force on human pulpal blood flow with laser-doppler flowmetry and concluded that pulpal blood flow was not altered during the application of a brief intrusive orthodontic force. [46]

Recent studies have demonstrated that low-energy laser irradiation stimulates bone formation *in vitro* and *in vivo*. Macrophage colony-stimulating factor (M-CSF) is essential and sufficient for osteoclastogenesis. Low-energy laser irradiation stimulates the velocity of tooth movement via the expressions of M-CSF .[47]

Conclusion:

Laser technology is widely used in dental research, diagnostics, and treatment. Orthodontics is not an exception. The clinical efficacy of laser therapy is well known and proper understanding of its properties can help orthodontists to use lasers in many fields and settings.

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