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Review Article

Recent Development of Laser Assisted Dentistry and Clinical Applications

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Abstract

Recent advancements in laser applications in clinical and dental medicine have the potential to play a critical role in patient comfort sectors, where laser technology is currently altering human existence. Laser drugs are used in dentistry and clinical therapy to counteract the negative effects of traditional methods, allowing for bloodless surgery with minimal postoperative discomfort and scarring. One of the key goals of laser dentistry is to provide the most comfortable care possible while minimizing risk. The advantages of laser therapy exceed the disadvantages, allowing for straight forward, modern, and safe clinical and dental procedures. This brief study's main subjects present the current state of the laser in a variety of therapeutic and dental applications

Keywords: Dentistry; Laser; Clinical; Laser safety

Introduction

Due to its many benefits over other conventional current procedures, laser (light amplification by stimulated emission of radiation) applications in dentistry and clinical medicine are now regarded as patient-friendly techniques. Lasers can be employed in a wide range of dental and clinical operations since they are available in a variety of devices and wavelengths [1]. Over the past few years, lasers have increasingly been used in clinical medicine and dentistry [2]. Lasers are recommended for a wide range of treatments due to their various benefits [3-6]. Conventional cavity preparation techniques include low- and high-speed hand pieces, which can be noisy, unpleasant, and stressful for patients [7-10].

Laser Types

Lasers in dental and clinical applications are classified based on a variety of criteria, including the laser's active medium, which can be gas, liquid, solid, or semi-conductor, and the excimer laser beam that will be emitted (Figure 1).

They are invariably classified according to the lasing medium used, as a gas laser or a solid laser. They can also be categorized based on tissue applicability in hard and soft tissue lasers, as well as wavelengths and the danger associated with laser application [11]. In addition, laser classification is based on different criteria such as power, source material (Figure 1), and wave length [12-14]. Another crucial factor in laser classification and treatment is power. Lasers are divided into three classes according to their power, as shown in the Figure 2: Low-power lasers (cold lasers): often less than 250mW cause light stimulation in tissues without having any heat consequences. This process is known as photobiostimulation. High-power lasers (warm or hard lasers) cause heat and improve the flow of energy in tissues to impart their therapeutic effects. The power of high-power lasers, which are usually more than 500mW, has applications in surgery. NdYAG (erbium-doped yttrium aluminum garnet) and Er:YAG (erbium-doped yttrium aluminum garnet) are classified as hard lasers and can be used on both hard and soft tissues, but they have limits due to their high cost and heat harm to the tooth pulp [12-14]. Furthermore, lasers are categorised according to their wavelength range, such as the ultraviolet range (300–400nm) and the visible light range (400–700nm).

Additionally, lasers are divided into groups based on their wavelengths, such as the visible light range (400–700nm) and the ultraviolet range (300–400nm). Figure 3 depicts the NIR (near infrared) spectrum from 700 to 1200nm and the infrared (FIR) region of greater than 1200nm [2,12].

Gas laser: The first gas laser was the helium neon laser, which had a green wavelength and multiple infrared wavelengths. Common examples of gas lasers are carbon dioxide and argon. A particular sort of gas is produced when noble gases such as argon, krypton, and xenon are mixed with reactive gases [15-17].

Although the carbon dioxide laser's bulkiness, high price, and destruction of hard tissue are its drawbacks, it is hydrophilic, has quick soft tissue removal, hemostasis with shallow depth penetration, and has maximal absorbency. Applications of the CO_2 laser in soft tissue surgery are generally accepted. Despite

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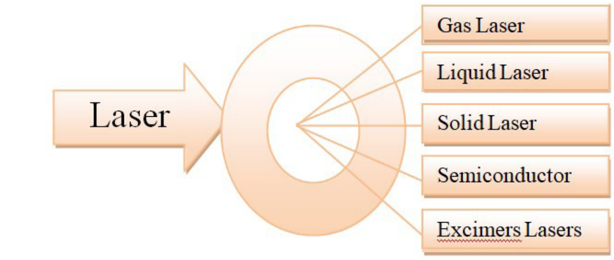

Figure 1: Types of lasers based source material.

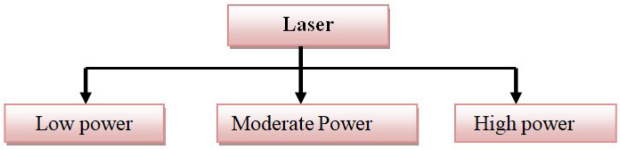

Figure 2: Types of lasers based power source.

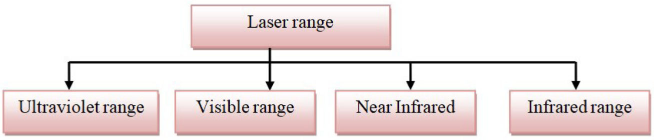

Figure 3: Laser classification based on wavelength range.

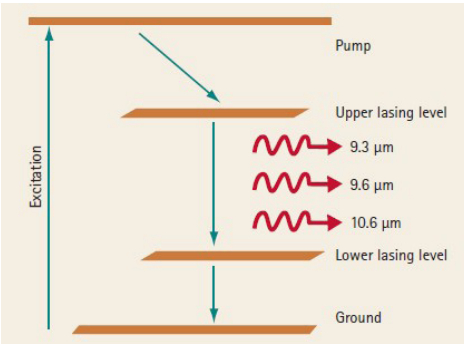

Figure 4: CO2 laser [18].

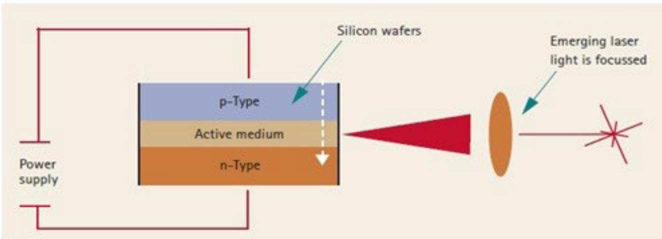

Figure 5: Diode Laser [18].

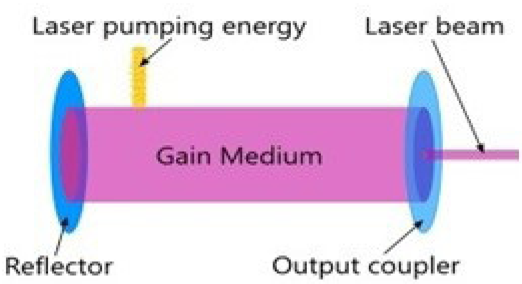

Figure 6: Diagram of a basic laser.

the use of CO_2 lasers for caries prevention, they have not been used in clinical settings as shown in Figure 4. Due to their advantageous optical properties, CO_2 wavelengths of 9,300 and 9,600nm can be used to treat dental hard tissue. Technological advances in software and laser settings will aid in the development of new therapeutic applications and techniques.

The availability and demand for CO_2 lasers as hard tissue lasers will both increase for researchers and medical professionals. Since water efficiently absorbs CO_2 lasers, they are absorbed on the surface of soft tissue. The first centimetre of soft tissue is where visible lasers (445–660nm) are most effectively absorbed because pigmented chromophores like melanin and hemoglobin absorb them [15-19].

Liquid laser: A liquid dye is stimulated by liquid lasers to produce light radiation. Most of their "tunable" range is between 550 and 590nm. Their light can be seen. Dye lasers are frequently utilised for vascular reasons, including the treatment of rosacea, spider nevi, and angiomas in children and newborns [20,21]. Other disorders, like psoriasis, where it is beneficial against new lesions, are treated with this type of laser less commonly [22,23].

Solid-state lasers: The medium can be ceramic, glass (neodymium glass), or a crystal (ruby, sapphire, titanium, etc.). There are also laser diodes, such as the ones used in CDs, in a non- exhaustive list.

The erbium laser: The two wavelengths of the erbium laser are the Er:YAG laser and the Er:Cr:YYSGG (yttrium scandium gallium garnet) laser. Because of its high affinity for hydroxyapatite and high water absorption rate, it is the best option for treating both hard and soft tissues that contain a high proportion of water. The erbium laser is a highly flexible laser technology used in dermatology. Because of its ability to be absorbed almost entirely by water, it is an excellent tool for treating a wide range of cutaneous skin problems [24-26]. The Nd:YAG laser is highly absorbed by pigmented tissue and has excellent hemostasis, making it ideal for surgically cutting and coagulating soft tissue.

Diode lasers: The size of laser machines has been significantly decreased thanks to the development of micro-structure diode cells that can produce laser light. The range of spectral emissions is now constrained to a very small band (about 400–1,000nm) due to the limitations of the underlying physics. These lasers only use active media made of solid materials. The active medium is placed between silicon wafers in a diode laser (Figure 4). It is possible to selectively polish the ends of the crystal relative to internal refractive indices to form entirely and partially reflecting surfaces, simulating the optical resonators of larger lasers. This is possible because the active media, such as GaAlAs, is crystalline.

Photons are released from the active medium when current is discharged across the active media from one silicon wafer to the next. Current surgically relevant diode lasers use banks of individual diode "chips" connected in parallel to obtain the needed power capability because individual diode "chips" produce relatively low energy output [27-29].

Table 1: Types of Laser.

Gas lasers	Liquid	Solid	Semiconductor	Excimers
• Argon • Carbon- dioxide [15-19]	• Dye lasers [20-23]	• Er: YAG laser • Er:Cr:YYSGG • Nd:YAG laser [24-26]	• GaAs laser (infrared) • GaAsP (visible) [34,35]	• Buffer gas (usually neon or helium), • Halogen gas(fluorine, chlorine,or bromine), • noble gas (argon, krypton, or xenon [36,37]

Semiconductor lasers: The semiconductor laser has found widespread use in the medical professions as a result of its benefits, including its compact size, light weight, long lifespan, and great efficiency. The function mechanism of the semiconductor laser have unique applications in the departments of ophthalmology, surgery, cosmetology, and dentistry are examined [30]. In medical applications, semiconductor lasers have two major mechanisms: bio-stimulation and thermal action. The activation of compensation, nutrition, repair, and other immune defense mechanisms in response to the stimulation response is the mobilisation of compensation, nutrition, repair, and other immune defense systems to remove the pathogenic process. The thermal effect is the most important biological effect because it is present in all laser irradiation. The heat consequences of a high-power semiconductor laser are the major reason for its use. The local irradiation from a laser causes a heated, high-temperature increase in the macro performance of the tissue's molecular absorption of photon energy, vibration, and rotation. Because tissue cells include pigments like melanin, hemoglobin, carotenoids, and other substances that can boost light absorption, the heat effect of lasers is more significant [31-33].

Excimers lasers: A mixture of noble gases and halogens is used as the gain medium in excimer lasers, which are strong ultraviolet lasers as shown in figure6. The power for excimer lasers comes from an electrical current source, like most gas lasers do. A tube that houses the laser medium is filled with three different types of gases, including buffer gas (usually neon or helium), halogen gas (fluorine, chlorine, or bromine), and noble gas (argon, krypton, or xenon). Excimer lasers' main benefit is their ability to generate a very narrow, accurate spot at a very short (UV) wavelength. Due to their ability to accurately obliterate material with minimal to no temperature buildup, excimer lasers are great for removing extra material through laser ablation. Compared to carbon dioxide lasers, which mainly rely on temperature accumulation to "boil off" material during ablation, this is the opposite [34,35].

Tabel 2: Applications of laser.

Applications		Reference
Clinical application	**Laser Application in Hard Tissues**	
	Caries detection	[22-37]
	Cavity Preparation	
	Carious Lesions Prevention	
	Etching	
	Fissure Sealant Therapy	
	Hard Tissue Cutting	
	Pulp Therapy	
	Laser Application in Soft Tissues	
	Ankyloglossia	
	Frenectomy	
	Gingival Remodeling and Gingivectomy	
	Lesions Removal and Biopsy	
	Herpetic Lesions	
Dentistry	Cellulitis and Spasm treatment	
	Teeth anesthesia	[38-44]
	Anterior dental Teeth Treatment	
Temporomandibular Joint (TMJ) Treatment		
	Surgical Operations and Injuries	
Biologic process	Biostimulation	[45-61]
	Photodynamic therapy (PDT)	
	Laser-Assisted Microdissection	
	The Optical Tweezers	
	The Laser Ablation	
	The Utilisation in imagery • Laser Coherence Tomography • Photoacoustic imaging (PAI) • Surface-enhanced Raman scattering(SERS)	

Laser Applications

Recently Lasers are commonly utilized in clinical medicine and dentistry for cavity and root canal preparations, scaling and root planning, gingival and periodontal procedures, coagulation and haemostasis, biopsies, tongue lesions excision, TMJ issues, implant exposure, and pre-prosthetic surgery. This section of present summarizes the recent advanced application of lasers in the field of clinical, dentistry and biological applications also Low Level Lasers which are used in stimulatory and inhibitory biologic process.

Clinical Application

The laser medicine is considered as a favorable technique in various areas such as clinical applications, dentistry and biological process due to its several advantages for patients compared to other current methods. The major principle in the application of laser is the use of light energy instead of rotation forces and sharp blades [1,22]. Lasers medication can also be classify into hard lasers and soft laser (cold lasers). Hard lasers offer both hard tissue and soft tissue clinical applications, but they are costly and possess a potential for non quantified thermal injury.

Dentistry: There are several different kinds of low level lasers, including the red visible Helium Neon (He-Ne), the invisible infrared Gallium-As, the gallium-aluminum-as, and the indium- gallium-aluminum-phosphode (InGaAlP). Low power lasers affect the target tissues by photochemical and photobiologic processes. Low level lasers have stimulatory and inhibitory effects and have a power output of 50–500mw. Their use in paediatric dentistry includes anaesthesia, the treatment of cellulitis and muscular spasms, the alleviation of temporomandibular joint issues, the attenuation of the gag reflex, and the decrease of postoperative sequelae [38-44].

Biologic Application

The wavelengths of the lasers employed in biological applications are either in the infrared or the ultraviolet range, and they can operate in continuous or pulse mode. The employment of the laser beam for the cutting of biological tissue is suited by its high power density and precise placement. Chemical bridges already present in the tissues will be destroyed by the high photon concentration [45-61].

Advantages and Disadvantages of Laser Applications

As with any application, there are benefits and drawbacks to laser technology. The dangers of laser surgery are similar to those of any form of surgery. Inadequate treatment of the issue, pain, infection, bleeding, scarring, and changes in skin colour are among the risks associated with laser surgery.

Table 3: Advantages and disadvantages of laser [62-64].

Advantages of laser	Disadvantages of laser
Less time spent the operator's chair compared to similar restorative treatment	Costs associated with purchasing and implementing technology are rather significant.
Engage with ailing tissues in a precise andselective manner	Laser operations require specialised knowledge andexpertise in a range of clinical applications.
Dry operating room and improved visibility	A change in clinical technique is necessary becausedental instruments are typically used for both side and end cutting.
Reduced requirement for antibiotics due to tissue surface sterilisation or decontaminatingcapabilities of the laser and bactericidal qualities on the tissue	Multiple lasers are required for different procedures since no one wavelength can effectivelycure all dental problems.
Excellent homeostasis and a decreased need forsutures	Erbium family lasers are unable to remove faultyrestorations made of metal and cast porcelain.
. Reduced oedema, scarring, and heat necrosis ofsurrounding tissue.	A rotary bur is faster at removing hard tissue than alaser.
Reduced use of local anaesthetics for treating softtissue	Dangerous to skin as well as to eyes, hence the entire professional team needs to wear particularwavelength eye protection.
Reduced post-operative discomfort and accelerated wound healing with a quicker healingresponse.	There may be a danger of disease transmission through laser-generated aerosol in immune- compromised patients receiving soft tissue therapy for viral lesions.
Increased acceptance of patients	
Little mechanical damage	
Compared to electrosurgical tools, lasers induceless thermal necrosis of nearby tissues.	
Removal of the high-speed drill and its related noise, vibrations, smells, and terror	
Contouring and removal of ossified tissue	

Conclusion

One of the greatest inventions of the twenty-first century, laser technology has advanced quickly over the past few decades. Laser is the most prominent innovative technology applicable in various areas, such as clinical, biological, and dental medicine. Lasers can be used to repair and regenerate tissue in addition to being utilised to improve aesthetics, diagnose disease, and remove damaged tissue. The clinician should be familiar with the physical properties, laser wavelengths, and how they interact with biological tissues, in addition to having completed the training program and learning curve at a comfortable speed. Through cutting-edge technologies like laser microdissection and photoablation, which at various levels of expression enable knowledge of the physiological mechanisms in the progression of a disease, the use of lasers in medicine and biology has proven its interest.

Author Statements

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