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Multidisciplinary Applications Of Lasers In Dentistry: A Comprehensive Review

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Abstract:
The advent of laser technology has introduced a paradigm shift in dentistry, offering minimally invasive alternatives to conventional treatment methods. Lasers provide precision, effective hemostasis, superior bacterial reduction, and improved patient comfort, while simultaneously enhancing wound healing and tissue regeneration. Their versatility allows applications ranging from diagnostic adjuncts to complex surgical procedures. Current evidence highlights their potential to improve clinical outcomes and patient satisfaction, though results remain heterogeneous due to variations in wavelength, parameters, and study design. Limitations such as high equipment costs, operator dependency, and the absence of standardized protocols continue to challenge their universal adoption. This comprehensive review consolidates available evidence on the multidisciplinary applications of lasers in dentistry, critically evaluating their efficacy, limitations, and future prospects in advancing dental care
Keywords: *Lasers, Dentistry, Peri-implantitis, Dental Caries*

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I. Introduction

Periodontal disease is a chronic, bacteria-driven inflammation that progressively and locally damages the tooth's supporting tissues—from the gums to the bone—resulting in pockets, recession, bone loss, and eventually tooth loss. Although multiple factors like age, smoking, hormonal changes, immune disorders, systemic conditions, and stress can influence periodontitis, the primary cause remains bacterial dental plaque, especially anaerobic gram-negative bacteria. As such, the initial phase of periodontal treatment involves non-surgical, etiological therapy aimed at reducing bacterial infection and controlling inflammation. To overcome this approach, laser therapy has been incorporated to evaluate its real-world effectiveness and patient satisfaction. When used alongside scaling and root planing (SRP), laser therapy appears to support better healing of periodontal sites. Different types of lasers are available in periodontology, each with distinct wavelengths and applications[1]

Over the past century, significant advancements have been made in the development of mechanical cutting instruments used in dentistry. Despite the technological progress in this field, many dental patients continue to express apprehension regarding the noise and vibrations associated with air turbines and ultrasonic scalers. Since the late 20th century, there has been a marked increase in the development and application of laser-based dental technologies, particularly those utilizing photomechanical interactions. The term "laser" is an acronym for "Light Amplification by Stimulated Emission of Radiation." Concurrently, the understanding and treatment approaches to periodontal disease have evolved considerably over the past three decades. The contemporary model of periodontal disease encompasses microbial factors, host immune responses, and individual risk factors that collectively influence disease progression. In this context, soft tissue lasers have emerged as valuable tools due to their effectiveness in bacterial reduction and haemostasis. These attributes make them particularly suitable for use in periodontally compromised sulci characterized by dark, inflamed tissues and pigmented bacterial presence.[2]

The first documented use of lasers in the treatment of dental caries was reported by Goldman et al in 1964. Subsequent research explored the neodymium-doped yttrium aluminium garnet (Nd:YAG) laser for caries prevention (Yamamoto & Sato) and the carbon dioxide (CO_2) laser for caries treatment (Melcer et al.).Laser applications in dentistry were initially favored due to their ability to reduce patient discomfort through minimal noise and vibration, alongside their ablative, haemostatic, and antimicrobial effects.

Despite these advantages, early lasers designed for soft tissue procedures proved unsuitable for treating dental hard tissues. The Nd:YAG laser, although useful in other contexts, was ineffective for hard tissue removal and posed risks of pulpal injury due to its deep tissue penetration.

Similarly, CO_2 lasers often caused undesirable effects such as enamel and dentin cracking, carbonization, and melting. As a result, the U.S. FDA approved CO_2, Nd:YAG, and diode lasers strictly for soft tissue applications within periodontics. Given that periodontal tissues comprise both soft and hard components, these earlier lasers were insufficient for comprehensive treatment. This limitation prompted the development of new laser technologies capable of safely addressing both tissue types. .[3]

Erbium-based lasers, including erbium:YAG (Er:YAG) and erbium, chromium:yttrium, scandium, gallium, garnet (Er,Cr:YSGG), demonstrated superior performance in hard tissue surgery.The Er:YAG laser exhibits significantly higher absorption in water than other lasers—2.5 times greater than Er,Cr:YSGG, and up to 15,000 times greater than Nd:YAG. This high water absorption enables precise ablation of both hard and soft tissues without affecting deeper layers.

In 1997, the FDA approved the Er:YAG laser for various procedures including cavity preparation, incisions, excisions, ablation, and haemostasis in oral tissues.

Owing to this versatility, erbium lasers have since been investigated for use in scaling, root debridement, and periodontal and peri-implant surgeries.

Their dual applicability offers promising potential in advancing periodontal therapy by addressing both soft and hard tissue concerns effectively[3]

History Of Lasers

- 1917 – Albert Einstein described the theory of stimulated emission.
- 1959 – Gordon Gould, a graduate student at Columbia University, introduced the concept of the laser in an article.
- 1960 –Theodore Maiman created the first ruby laser at Hughes Research Laboratories based on theoretical research by Charles H. Townes and Arthur Leonard Schawlow

- 1961 – Javan et al. developed the first gas laser and the first continuously operating laser.
- 1964 – Patel created the CO_2 laser at Bell Laboratories.
- 1971 – Hall and Jako et al. studied tissue reactions to laser light and its effects on wound healing.
- 1974 – Nd:YAG laser introduced by Geusic et al.
- 1977 – Argon (Ar) laser introduced by Kiefhaber.
- 1980s – Lasers began to be used in oral surgery to remove soft-tissue lesions.
- 1987 – Nd:YAG laser was specifically developed for dental procedures.
- 1988 – Er:YAG laser introduced by Hibst and Paghdiwala.
- 1989 – Midda et al. applied the Nd:YAG laser for soft tissue surgery in dentistry
- 1990 – FDA – Approved use of laser therapy in intraoral gingival and mucosal tissue surgery
- 1990 – Myers – Introduced the first laser specifically for dentistry
- 1994 – Morita – Introduced Nd: YAG lasers in endodontics
- 1998 – Mazeki et al. – Did root canal shaping with Er: YAG laser.

Classification And Types Of Laser

Lasers used in dental practice can be classified by various methods: According to the lasing medium used, such as, gas laser and solid laser; according to tissue applicability, hard tissue and soft tissue lasers; according to the range of wavelength [Figure 1], and of course the risk associated with laser application[6]

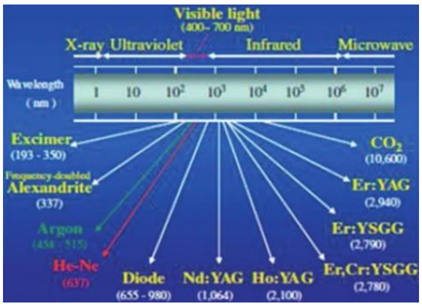

Figure 1: Various types of lasers and theirs corresponfing wavelengths [6]

CLASSIFICATION	TYPES
1. According to ANSI and OSHA Class I Class II (a) Class II (b) Class III (a) Class III (b) Class IV	 Low-powered lasers, safe to naked eye. E.g., Laser pointer device Low-powered lasers, hazardous when viewed >1000 s by naked eye. E.g., He-Ne lasers Low-powered visible lasers, hazardous if viewed for>0.25 s Medium-powered lasers, hazardous if viewed for >0.25 s without magnifying Medium powered lasers (0.5 W max), hazardous if viewed directly High-powered lasers (>0.5 W), produces ocular, skin, and fire hazards
2. Based on wavelength or spectrum a) Ultraviolet lasers (100-400 nm) b) Visible lasers (400-750 nm) c) Infrared lasers (750-10,000 nm)	 E.g., Excimer, alexandrite E.g., Argon, He-Ne E.g., Diode, Nd: YAG, Ho: YAG, Er, Cr: YSGG, Er: YAG, CO2
3. Based on pulsing a) Pulsed lasers b) Non-pulsed lasers	 Excimer, Nd:YAG Diode
4. Based on type of active medium used : a) Gas lasers b) Solid state crystal lasers c) Semiconductor lasers d) Excimers e) Liquid	 CO2, He-Ne, argon lasers Ruby lasers, Nd:YAG, Er:YAG, diode Diode lasers, Gas lasers Argon fluoride, krypton fluoride, xenon fluoride Dyes
5. According to emission modes CW and Free-running pulsed	He-Ne lasers, diode Free-running pulsed CO2. argon, Nd:YAG, Er, Cr:YSGG Free-running pulsed CO2. argon, Nd:YAG, Er, Cr:YSGG

Table 2: Classification of lasers [5]

Mechanism Of Action Of Laser

Laser light is monochromatic, meaning it comprises a single wavelength within the electromagnetic spectrum. A laser system typically consists of three primary components:

- An energy source,
- An active lasing medium, and
- A set of two or more mirrors forming an optical cavity or resonator.

To initiate light amplification, external energy is supplied to the laser system through a process known as pumping. This can be achieved using various mechanisms such as a flashlamp, electrical current, or electromagnetic coil. The supplied energy excites the atoms or molecules within the active medium, which is housed inside the optical resonator, leading to the spontaneous emission of photons.

These photons then undergo amplification by stimulated emission as they are reflected repeatedly between the highly reflective surfaces of the resonator. This controlled environment increases the number of coherent photons before they are released through the partially reflective output coupler, resulting in a concentrated laser beam. [6]

In dental applications, the generated laser light is conveyed to the target tissue through various delivery systems, including fiberoptic cables, hollow waveguides, or articulated arms. Additionally, the system is often equipped with focusing lenses, a cooling mechanism, and other regulatory controls to optimize performance and ensure safety during clinical procedures.

The wavelength and other optical characteristics of a laser are primarily determined by the composition of its active medium, which may consist of a gas, crystal, or solid-state semiconductor. These characteristics dictate how laser energy interacts with biological tissues.

Laser light can interact with target tissues in four fundamental ways:

1. Reflection
2. Transmission
3. Scattering
4. Absorption.

Among these, absorption is the most critical for clinical applications. When laser energy is absorbed by tissue, it raises the temperature of the tissue and may induce photochemical effects, depending on the water content of the target. At 100°C, water within the tissue vaporizes, leading to ablation. At temperatures between

60°C and 100°C, protein denaturation occurs without tissue vaporization. If temperatures exceed 200°C, tissue undergoes dehydration followed by burning, resulting in carbonization, which is typically undesirable.[6]

Effective absorption of laser energy requires the presence of chromophores, which are light-absorbing molecules with specific affinities for particular wavelengths. In intraoral soft tissues, the primary chromophores are melanin, hemoglobin, and water, whereas in dental hard tissues, water and hydroxyapatite serve this function.

Since different wavelengths exhibit varying absorption coefficients for these chromophores, the selection of a suitable laser must be carefully tailored to the clinical procedure and target tissue involved. [7]

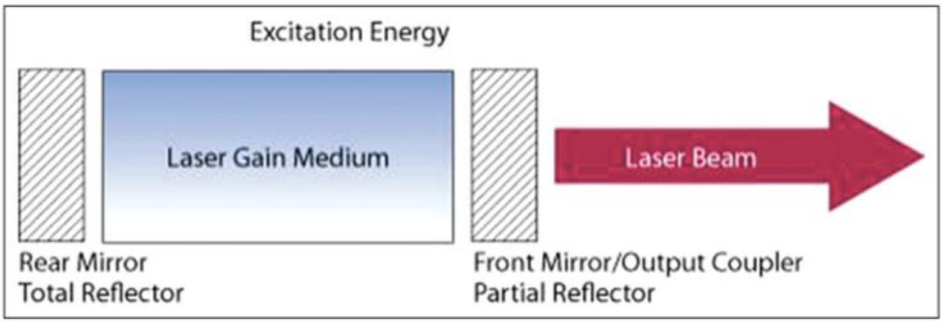

Figure 2: Mechanism of action of the laser

Types Of Lasers:
Carbon Dioxide Laser

The CO2 laser wavelength has a very high affinity for water, resulting in rapid soft tissue removal and hemostasis with a very shallow depth of penetration. Although it possesses the highest absorbance of any laser, disadvantages of the CO2 laser are its relative large size and high cost and hard tissue destructive interactions.[8]

Neodymium Yttrium Aluminum Garnet Laser

The Nd: YAG wavelength is highly absorbed by the pigmented tissue, making it a very effective surgical laser for cutting and coagulating dental soft tissues, with good hemostasis. In addition to its surgical applications.() there has been research on using the Nd: YAG laser for nonsurgical sulcular debridement in periodontal disease control and the Laser Assisted New Attachment Procedure (LANAP)

Erbium Laser

The erbium 'family' of lasers has two distinct wavelengths, Er, Cr: YSGG (yttrium scandium gallium garnet) lasers and Er: YAG (yttrium aluminum garnet) lasers. The erbium wavelengths have a high affinity for hydroxyapatite and the highest absorption of water in any dental laser wavelengths.

Consequently, it is the laser of choice for treatment of dental hard tissues. In addition to hard tissue procedures, erbium lasers can also be used for soft tissue ablation, because the dental soft tissue also contains a high percentage of water

Diode Laser

The active medium of the diode laser is a solid state semiconductor made of aluminum, gallium, arsenide, and occasionally indium, which produces laser wavelengths, ranging from approximately 810 nm to 980 nm. All diode wavelengths are absorbed primarily by tissue pigment (melanin) and haemoglobin. Conversely, they are poorly absorbed by the hydroxyapatite and water present in the enamel. Specific procedures include aesthetic gingival re-contouring, soft tissue crown lengthening, exposure of soft tissue impacted teeth, removal of inflamed and hypertrophic tissue, frenectomies, and photostimulation of the apthous and herpetic lesions

Table 3: Characteristics Of Laser Used In Dentistry

Laser Type	Common Abbreviation	Wavelength	Waveform	Delivery Tip	Clinical Applications
Carbon dioxide	CO_2	10.6 µm	Gated or Continuous	Hollow waveguide beam focused when 1 to 2 mm from a target surface	Removes soft tissue lesions.
Neodymium: yttrium aluminum-garnet	Nd:YAG	1.064 µm	Pulsed	Flexible fiber optic system of varying diameters; surface contact required for most procedures	Soft tissue incision and ablation; subgingival curettage and bacterial elimination
Holmium: yttrium aluminum-garnet	Ho:YAG	2.1 µm	Pulsed	Flexible fiber optic system; surface contact required for most procedures	Soft tissue incision and ablation; subgingival curettage and bacterial elimination
Erbium: yttrium aluminum-garnet	Er:YAG	2.94 µm	Free-running pulsed	Flexible fiber optic system or hollow waveguide; surface contact required for most procedures	Soft tissue incision and ablation; subgingival curettage; scaling of root surfaces; osteoplasty and ostectomy
Erbium, chromium: yttriumselenium galliumgarnet	Er,Cr:YSGG	2.78 µm	Free-running pulsed	Sapphire crystal inserts of varying diameters; surface contact required for most procedures	Dental caries removal, Soft tissue incision, and ablation; subgingival curettage; osteoplasty and ostectomy
Neodymium: yttrium aluminum-perovskite	Nd:YAP	1,340 nm	Pulsed	Flexible fiber optic system; surface contact required for most procedures	Soft tissue incision and ablation; subgingival curettage and bacterial elimination
Indium-galliumarsenide-phosphide; gallium aluminum arsenide; galliumarsenide	InGaAsP (diode) GaAlAs (diode) GaAs (diode)	Diodes can range from 635 to 950nm	Gated or Continuous	Flexible fiber optic system; surface contact required for most procedures	Soft tissue incision and ablation; subgingival curettage and bacterial elimination

Use Of Lasers In Dentisry
Use Of Lasers In Soft Tissue Procedure:
Prosthodontics
Gingival Contouring / Crown Lengthening
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)
Benefits: Improves crown exposure, precise tissue removal, minimal bleeding, faster healing[13]

Pre-Prosthetic Surgery / Vestibuloplasty & Hyperplastic Tissue Removal[13]
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)
Benefits: Precise soft tissue modification, reduced bleeding, faster healing, optimal prosthetic fit

Excision of Oral Mucosal Lesions (Fibroma, Pyogenic Granuloma, Hyperplastic Tissue)
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm) [13]
Benefits:
1. Precise tissue removal with minimal bleeding
2. Reduced postoperative pain and swelling
3. Enhanced healing and patient comfort

Frenectomy
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm)
Benefits:
i. Atraumatic removal of abnormal frenal attachments
ii. Minimal bleeding, faster healing

iii. Improves functional outcomes for tongue and lip movement[14]

Biopsy Procedures
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm)
Benefits:

i. Provides clean incision margins
ii. Reduces intraoperative bleeding
iii. Preserves tissue integrity for histopathological examination[13]

Incision and Drainage of Oral Abscesses
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm)
Benefits:

i. Precise incision with hemostasis
ii. Minimizes trauma to surrounding tissue
iii. Reduces postoperative discomfort and infection risk[14]

Hemostasis During Oral Surgical Procedures
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm)
Benefits:

i. Seals small blood vessels instantly
ii. Provides clear surgical field
iii. Reduces need for sutures and improves visibility[13]

Endodontics

Root Canal Disinfection
Laser Type & Wavelength: Diode (810–980 nm), Er:YAG (2,940 nm)
Benefits: Antimicrobial effect, alternative to chemical disinfectants

Photobiomodulation / Post-surgical Healing
Laser Type & Wavelength: Diode (630–980 nm), Er:YAG (2,940 nm)
Benefits: Supports soft tissue regeneration, reduces inflammation, accelerates healing.[15]

Uses Of Lasers In Hard Tissue Procedures

Photochemical effects

The argon laser produces high intensity visible blue light (488 nm), which is able to initiate photopolymerization of light-cured dental restorative materials, which use camphoroquinone as the photoinitiator.Argon laser radiation is also able to alter the surface chemistry of both enamel and root surface dentine,which reduces the probability of recurrent caries. The bleaching effect relies on the specific absorption of a narrow spectral range of green light (510-540 nm) into the chelate compounds formed between the apatites, porphyrins, and tetracycline compounds. Argon and Potassium Titanyl Phosphate (KTiOPO4, KTP) lasers can achieve a positive result in cases that are completely unresponsive to conventional photothermal 'power' bleaching.[6]

Cavity preparation, caries, and restorative removal

Various studies depict the use of Er: YAG, since 1988, for removing caries in the enamel and dentine by ablation, without the detrimental effect of rise in temperature on the pulp [16] even without water-cooling,with low 'fluences' laser (LLLT), similar to air-rotor devices, except that the floor of the cavity is not as smooth. The Er: YAG laser is capable of removing cement, composite resin, and glass ionomer.

Etching

Laser etching has been evaluated as an alternative to acid etching of enamel and dentine. Enamel and dentine surfaces etched with (Er, Cr: YSGG) lasers show micro-irregularities and no smear layer. Adhesion to dental hard tissues after Er: YAG laser etching is inferior to that obtained after conventional acid etching [17]

Treatment of dentinal hypersensitivity

Comparing the desensitizing effects of an Er:YAG laser with conventional agents on cervically exposed sensitive dentin have shown that the Er:YAG laser effectively reduces sensitivity and provides longer-lasting relief than traditional desensitizing treatments.

Uses Of Laser In Periodontics
Non-Surgical Periodontal Therapy:
Nd: YAG and Diode lasers

Diode lasers, operating in the 810–1064 nm range, produce light absorbed by tissue and bacterial pigments, leading to a photothermal effect. This makes them highly effective for soft tissue procedures such as gingival contouring and sulcular debridement.[18]

They significantly aid in bacterial reduction within periodontal pockets, a key factor in periodontal therapy. Their hemostatic properties ensure better bleeding control, enhancing procedural safety. Additionally, diode lasers are used for facial depigmentation, removal of lesions like pyogenic granulomas, and they promote faster wound healing, offering both therapeutic and post-procedural benefits. Study in 2019 by Chandra S. and colleagues, has demonstrated the positive effects of the use of diode lasers (808 nm; 1.5 to 1.8 W; continuous mode) in the management of periodontal disease in patients with type 2 diabetes. It was shown that the combination of the laser and the SRP showed improvement in the periodontal clinical parameters as well as reduction of Porphyromonas gingivallis and Aggregatibacter actinomycetemcomitans bacteria, compared to treatment with the SRP alone. This was accomplished by positioning the optical fiber inside the periodontal pocket and directing it to the soft tissue. The removal of the sulcular epithelium from the periodontal pocket (sulcular debridement) and the promotion of the reduction of periodontopathogenic bacteria, supra- or subgingival, are both indicated uses for the Nd:YAG laser and the diode laser.

Er: YAG and Er, Cr: YSGG lasers:

Water molecules within hydroxyapatite crystals exhibit strong absorption of Er:YAG (2940 nm) and Er,Cr:YSGG (2780 nm) laser wavelengths. Equipped with a cooling system, these lasers produce photomechanical or photothermal effects without significantly heating adjacent tissues, allowing efficient removal of mineralized structures.

Notably, hydroxyapatite shows particularly high absorption of the Er,Cr:YSGG laser. Er:YAG and the Er, Cr; YSGG lasers stimulate changes in the surface that make them more uneven and rough. These surface modifications are the result of the explosive ablation process that these lasers are known for, which maintains biocompatible surfaces when employed with the proper irradiation conditions. These lasers are also recommended for dental calculus removal, non-surgical periodontitis treatment (bacterial reduction), and soft tissue ablation operations [19]

Surgical Periodontal Therapy

High-power lasers such as CO_2 (10,600 nm), Nd:YAG (1064 nm), diode lasers (800–980 nm), Er:YAG (2940 nm), and Er,Cr:YSGG (2780 nm) are considered most suitable for soft tissue surgical applications. Common indications include subgingival curettage, excisional biopsy, removal of pathological soft tissues (e.g., granuloma, fibroma), frenectomy, gingivectomy/gingivoplasty, melanin depigmentation, crown lengthening, proximal wedge procedures, flap de-epithelialization in regenerative therapy, and subgingival curettage.

Osteotomy and osteoplasty performed using an Er,Cr:YSGG laser or drill have been evaluated in animal studies, showing that Er,Cr:YSGG provides favorable healing due to the absence of carbonization and debris. It is proven to be a safe and precise technique, allowing controlled cutting depth when appropriate irradiation, cooling, and beam angulation parameters are applied.[19]

Low-Level Laser In Periodontology
Photobiomodulation Therapy (PBM)

PBM uses lasers in the visible or near-infrared range (630–980 nm) as an adjunct to non-surgical periodontal therapy, aiding in inflammation control, tissue repair, edema reduction, and dentin hypersensitivity management. It has also shown benefits in surgical cases by accelerating gingival and bone healing and reducing postoperative discomfort. PBM has demonstrated positive effects in diabetic patients with periodontitis, reducing gingival inflammation and improving outcomes. PBM can complement both surgical and non-surgical periodontal therapies for plaque-associated or non-plaque-associated gum diseases, including periodontitis.

Antimicrobial Photodynamic Therapy (aPDT)

Photodynamic therapy (PDT), also called phototherapy or photochemotherapy, is a minimally invasive treatment that has gained attention in dentistry since its introduction in the 1960s. It works by activating a photosensitizing agent, such as methylene blue or toluidine blue, with light of a specific wavelength in the presence of oxygen, producing reactive oxygen species that destroy microorganisms.

aPDT combines a photosensitizer (e.g., methylene blue or toluidine blue) with light of a specific wavelength to generate a photochemical reaction that targets pathogenic bacteria. aPDT has been shown to decrease bleeding, reduce inflammation, and temporarily lower bacterial load; however, improvements in clinical attachment level remain inconsistent. It also offers outcomes comparable to systemic antibiotics (amoxicillin + metronidazole) as an adjunct in non-surgical periodontitis therapy.[20]. In periodontal therapy, antimicrobial PDT is explored as an adjunct to scaling and root planing; however, clinical outcomes remain controversial due to wide variations in protocols, including pre-irradiation time, light power (60–280 mW), exposure duration, number of sessions, and type/concentration of photosensitizers.

Lasers In Implant:

Implant placement:

Minimally invasive implant placement with the tissue punch technique is ideal when sufficient bone dimensions are available. Er:YAG hard tissue lasers are employed to create the initial access by precisely removing soft tissue and cortical bone in a circular manner, followed by completing the osteotomy with a drill. This method provides greater accuracy, reduces surgical trauma, minimizes discomfort, and promotes faster healing and better bone-to-implant contact compared to traditional drills.[21] The use of lasers eliminates the need for flap elevation and suturing, resulting in less postoperative inflammation, a sterile surgical field, and improved patient comfort. A surgical guide can also be utilized to ensure accurate laser-assisted implant placement.

Uncovering implants in the second stage

Lasers are widely used for uncovering implants in stage II surgery, offering precision, minimal trauma, and better patient comfort. CO_2 and Er:YAG lasers are preferred, while Nd:YAG is avoided due to heat-related risks. The technique preserves attached gingiva, prevents bone remodeling, and provides hemostasis, faster healing, and improved visibility. The laser tip is positioned at a 45° angle and moved continuously to avoid heat concentration. Benefits include excellent hemostasis, enhanced visibility of the cover screw, formation of a protective coagulum that supports healing, and greater patient comfort. It also allows impressions to be taken in the same appointment.[21]

Management of peri-implantitis

Peri-implantitis is a rapidly progressing condition characterized by loss of osseointegration due to bacterial toxins, leading to inflammation and bone resorption. In such cases, implant surfaces become contaminated with bacteria, soft tissue cells, and bacterial by-products. Mechanical instrumentation alone cannot completely eliminate plaque and endotoxins from implant threads.[22]

Laser-assisted debridement and degranulation using wavelengths safe for bone have shown effectiveness. CO_2, diode, and Er:YAG lasers can remove plaque and calculus from implant abutments without damaging their surfaces, whereas Nd:YAG lasers, despite strong sterilization properties, are contraindicated due to excessive heat generation and surface alterations. Studies by Kreisler et al. concluded that Nd:YAG and Ho:YAG are unsuitable for implant surface decontamination at any power setting. Er:YAG and CO_2 can be used cautiously at controlled power levels, while GAAlA lasers demonstrated no surface damage.

Implant explantation:

With the rising use of dental implants, the incidence of implant failure has also increased, often necessitating surgical removal through techniques like block resection, buccal ostectomy, or trephine osteotomy. Er,Cr:YSGG lasers offer a minimally invasive alternative, effectively cutting bone without burning, melting, or altering its mineral composition. The laser's hydrokinetic mechanism, using air-water spray, creates clean cuts via micro explosions, minimizing thermal damage. Additionally, laser-assisted explantation can decontaminate surrounding tissues and support uncomplicated healing.[23].

Comparative Role of Laser and it's wavelengths in Periodontal Surgery

Gingivectomy & Gingival Contouring[14]

Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)

Benefits: Precise tissue removal, minimal bleeding, reduced anesthesia, faster recovery

Frenectomy

Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)

Benefits: Reduced trauma, precise excision, enhanced postoperative comfort.

Periodontal Pocket Therapy

Laser Type & Wavelength: Diode (810–980 nm), Nd:YAG (1,064 nm), Er:YAG (2,940 nm)

Benefits: Reduction in bacterial load, tissue ablation, improved microbial control[24]

LANAP (Laser-Assisted New Attachment Procedure)
Laser Type & Wavelength: Nd:YAG (1,064 nm)
Benefits: Promotes new periodontal attachment, reduces pocket depth, accelerates healing[24]

Implant Dentistry
Peri-implantitis Management
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)
Benefits: Implant surface decontamination, reduced inflammation, enhanced healing

Soft Tissue Management / Implant Uncovering (Stage II Surgery)
Laser Type & Wavelength: Diode (810–980 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm)
Benefits: Minimally invasive, preserves attached gingiva, hemostasis, faster recovery, allows immediate impressions

Advantages and Disadvantages of LASER

- **Reduced bleeding**
  - Lasers coagulate blood vessels during surgery, leading to less intraoperative and postoperative bleeding.
  - *Clinical relevance:* Laser reduces bleeding and eliminates the need for sutures.
- **Minimized damage to surrounding tissues**
  - High precision of lasers results in faster recovery and reduced swelling.
  - *Clinical relevance:* Minimal damage allows for faster healing and less patient discomfort.
- **Lower risk of infection**
  - Lasers sterilize the surgical site, reducing bacterial contamination.
  - *Clinical relevance:* Useful in excising lesions or treating periodontitis, lowering secondary infection risk.

Disadvantages:

- **High cost of equipment**
  - Expensive technology makes lasers less accessible for smaller dental practices and increases treatment costs.
  - *Clinical relevance:* Clinics may not afford laser technology, limiting availability.
- **Limited penetration depth**
  - Lasers are less effective in deep soft tissue surgeries.
  - *Clinical relevance:* Procedures requiring deep tissue work may still need conventional methods.
- **Need for specialized training**
  - Practitioners require additional training, which may restrict adoption.
  - *Clinical relevance:* Clinics lacking trained personnel may face challenges implementing laser technology.

II. Conclusion:

In summary, laser technology is reshaping the future of dentistry through its refined precision, minimally invasive nature, and capacity to stimulate biological healing processes. It enhances clinical efficiency by reducing procedural discomfort and recovery time, while enabling deeper, more targeted disinfection. With the advent of artificial intelligence and growing global accessibility, lasers are not merely tools but transformative assets—poised to redefine the therapeutic boundaries and elevate the standards of modern dental care.