College of Al-Mustaqbal University
Faculty of Dentistry

The Role of Laser in Dentistry

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Dedication

In the name of Allah, the Most Gracious, the Most Merciful
To those whose prayers have been our greatest support after Allah…
To our beloved families, our fathers and mothers, who have given love, effort, and patience, and who were—after Allah—the reason we reached this level of knowledge and success…
To our brothers and sisters, who shared our joys and stood by us in difficult times, lightening the burden of the journey…
To our dear friends and classmates, who shared with us the late nights of studying, the exams, the effort, and the unforgettable memories…
To everyone who believed in us, supported us with a kind word, or remembered us in a sincere prayer…
We dedicate this humble work, asking Allah Almighty to make it a step on the path of serving knowledge and the field of dentistry, and to reward them and us with all that is good.

بِسْمِ اللهِ الرَّحْمَنِ الرَّحِيمِ

﴿وَمَا تَوْفِيقِي إِلَّا بِاللَّهِ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ﴾

Acknowledgment

In the name of Allah, the Most Gracious, the Most Merciful
"And my success is not but through Allah. Upon Him I have relied, and to Him I return."
All praise is due to Allah, Lord of the worlds. May peace and blessings be upon the most noble of Prophets and Messengers, our Prophet Muhammad, and upon his family and companions.
In light of the saying of the Prophet (peace and blessings be upon him): *"Whoever does not thank people has not thanked Allah,"* we would like to express our deepest gratitude and sincere appreciation to everyone who contributed to the completion of this humble work.
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All praise is due to Allah, Lord of the worlds.

Abstract

The term LASER is an acronym for *Light Amplification by Stimulated Emission of Radiation*. Since its first application in dentistry by Maiman in 1960, laser technology has been used for a wide range of hard and soft tissue procedures in the oral cavity. Laser irradiation has become a useful tool in many fields of medicine, dentistry, biology, physiotherapy, and other life sciences. The clinical use of laser energy is based on different physical phenomena related to the interaction of light with biological tissues, cells, and fluids.

In hard tissue applications, lasers are used for caries prevention, bleaching, restorative removal and curing, cavity preparation, treatment of dentinal hypersensitivity, growth modulation, and for diagnostic purposes.

In soft tissue applications, lasers are used in wound healing, removal of hyperplastic tissue, uncovering impacted or partially erupted teeth, photodynamic therapy for malignancies, and photostimulation of herpetic lesions. Low level laser therapy (LLLT) has also been established in clinical dentistry because of its anti-inflammatory, biostimulant, and regenerative effects, with widely reported satisfactory clinical outcomes.

This review focuses on both hard and soft tissue applications of lasers in dentistry, describes laser–tissue interactions, summarizes clinical uses such as temporomandibular disorders (TMD), dry socket, mucoceles, ranulas, oral leukoplakia, oral lichen planus, gingival pigmentation, and presents the effectiveness of different laser types (He–Ne, diode, CO_2, Nd:YAG, Er:YAG, Er,Cr:YSGG and WaterLase systems), along with their advantages, limitations, and safety considerations.

Keywords: Laser, Dentistry, Hard tissue, Soft tissue, Low level laser therapy, Diode laser, CO_2 laser, Nd:YAG, Er:YAG, Er,Cr:YSGG.

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List of Abbreviations

Abbreviation	Meaning
LASER	Light Amplification by Stimulated Emission of Radiation
LLLT	Low Level Laser Therapy
LILT	Low Intensity Laser Therapy
TMJ	Temporomandibular Joint
TMD	Temporomandibular Disorders
AO	Alveolar Osteitis (Dry Socket)
OLP	Oral Lichen Planus
He–Ne	Helium–Neon Laser
CO_2	Carbon Dioxide Laser
Nd:YAG	Neodymium:Yttrium–Aluminum–Garnet Laser
Er:YAG	Erbium:Yttrium–Aluminum–Garnet Laser
Er,Cr:YSGG	Erbium, Chromium:Yttrium–Scandium–Gallium–Garnet Laser

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Chapter One: Introduction

1.1 Introduction

The term LASER is an acronym for “Light Amplification by the Stimulated Emission of Radiation”. Since its first application in dentistry by Maiman in 1960, the laser has been used in various hard and soft tissue procedures. Oral soft tissue uses are becoming increasingly common in dental offices.

Despite the multiple potential uses of lasers in dentistry—beyond soft tissue surgery and dental composite curing—many of these possibilities have not yet been fully realized clinically. These include the replacement of the dental drill with a laser, laser-based dental decay prevention, and laser-assisted decay detection.

Over the last two decades, there has been an explosion of research on laser applications. Laser irradiation has become a useful tool for many procedures in medicine, dentistry, biology, physiotherapy, and other life sciences. The clinical use of laser irradiation is based on a wide range of physical phenomena involving light interaction with biological tissues, cells, and fluids.

In hard tissue applications, lasers are used for:

Caries prevention

Bleaching

Restorative removal and curing

Cavity preparation

Treatment of dentinal hypersensitivity

Growth modulation

Diagnostic purposes

In soft tissue applications, lasers are used for:

Wound healing

Removal of hyperplastic tissue

Uncovering impacted or partially erupted teeth

Photodynamic therapy for malignancies

Photostimulation of herpetic lesions

Laser light is monochromatic, collimated, coherent, and intense, produced by stimulated emission of radiation from a light source. Lasers are classified according to several factors, including classification based on the active medium (gas, liquid, solid, or semiconductor), which determines the type of emitted laser beam. The properties of a specific laser beam—particularly wavelength and the optical characteristics of the target tissue—determine the type and extent of interaction that may occur. Low level laser therapy (LLLT), which has therapeutic effects without inducing significant heat, is well established in clinical dentistry because of its anti-inflammatory, biostimulant, and regenerative effects, with widely reported satisfactory clinical results.

1.2 Aim of the Study

The aim of this review is to focus on the hard as well as soft tissue applications of laser in dentistry.

1.3 Advantages of Laser in Dentistry

The advantages of laser use in dentistry can be summarized as follows:

In some procedures, **no local anesthesia** is required.

Reduced risk of bacterial infection, as the laser has a sterilizing effect on the treated area.

Decreased need for sutures in many soft tissue procedures.

Minimal bleeding, because the laser promotes blood clotting and coagulation.

Faster healing times after surgery.

Less postoperative pain and swelling compared with conventional methods.

Less damage to surrounding tissues, as the focused light allows the dentist to act precisely on damaged tissue while leaving healthy tissue largely untouched.

Reduced anxiety and increased comfort for patients due to reduced noise and vibration.

Reduced need for medications and antibiotics after treatment in many cases.

Lower risk of infection due to antimicrobial properties of laser energy.

1.4 Disadvantages of Laser in Dentistry

Although lasers provide many benefits, they also have limitations:

Lasers cannot be used to fill cavities located between teeth, around old fillings, or large cavities that require preparation for a crown.

Lasers cannot be used to remove defective crowns or amalgam (silver) fillings, nor to prepare abutment teeth for bridges.

Traditional rotary drills may still be necessary to shape the filling, adjust occlusion, and polish the restoration, even when a laser is used.

Lasers do **not** eliminate the need for anesthesia; in many procedures, local anesthesia is still required.

Laser treatments are usually more expensive because the cost of the laser unit is much higher than that of a conventional dental drill.

1.5 Applications of Laser

1.5.1 Low Intensity Laser Energy Applications

Diagnosis: caries and calculus detection

Low level laser therapy (LLLT) / Low intensity laser therapy (LILT)

Photo-activated decontamination

Hemostasis and coagulation

Tooth whitening

1.5.2 High Intensity Laser Energy Applications

Bacterial decontamination

Soft tissue ablation (cutting)

Enamel ablation

Dentin ablation

Osseous (bone) ablation

Depigmentation of melanin and other endogenous pigments

1.5.3 Soft Tissue Applications

Wound healing

Management of post-herpetic neuralgia and aphthous ulcers

Photodynamic therapy for malignancies

Aesthetic gingival recontouring and crown lengthening

Exposure of unerupted and partially erupted teeth

Frenectomy procedures

1.5.4 Hard Tissue Applications

Cavity preparation and caries removal

Removal of restorative materials

Treatment of dentinal hypersensitivity

Diagnostic applications

Use of 3-D laser scanners for electronic model (e-model) preparation

1.6 Laser Safety

While most dental lasers are relatively simple to operate, certain precautions must be taken to ensure safe and effective use:

Protective eyewear specific to the laser wavelength must be worn by everyone in the vicinity of the laser while it is in use: the dentist, chair-side assistants, patient, and any observers.

Accidental exposure of non-target tissues can be prevented by:

Posting **warning signs** outside the nominal hazard zone

Limiting access to the surgical environment

Minimizing reflective surfaces

Ensuring that the laser is in good working order and that all manufacturer safeguards are in place

To prevent exposure to infectious pathogens, **high-volume suction** should be used to evacuate any vapor plume created during tissue ablation, and standard infection-control protocols should be followed.

Each office should designate a **Laser Safety Officer** to supervise proper laser use and coordinate staff training.

Chapter Two: Laser–Tissue Interactions and Clinical Applications

2.1 Laser and Tissue Interactions

The light energy emitted by a laser can have four different interactions with the target tissue. These interactions depend on the optical properties of the tissue and the wavelength used.

Transmission

Laser energy passes through the tissue without significant interaction or effect on the target. For example, water is relatively transparent to Nd:YAG wavelengths, whereas tissue fluids readily absorb CO_2 laser energy.

Absorption

This is the most desirable effect in clinical dentistry. The amount of energy absorbed by the tissue depends on its characteristics (such as pigmentation and water content), as well as the laser wavelength and emission mode.

Diode and Nd:YAG lasers have high affinity for melanin and less interaction with hemoglobin.

Longer wavelengths (e.g., Erbium and CO_2) interact strongly with water and hydroxyapatite.

Shorter wavelengths from around 500–1000 nm are readily absorbed in pigmented tissues.

Scattering (Diffusion)

Scattering of laser light within the tissue weakens the energy and may result in no useful biological effect.

Reflection

As the laser beam exits the handpiece and travels through air, it becomes more divergent with distance. Reflection from surfaces can make the beam hazardous if not properly controlled.

2.1.1 Types of Tissue Interactions

Photochemical Effects

Lasers can initiate or accelerate chemical reactions, such as curing composite resins. They can also cause breakdown of chemical bonds, as in photodynamic therapy, where a photosensitizer is activated to destroy target cells.

Photoablation

When laser energy is absorbed, tissue temperature rises. At about 100 °C, water within tissues vaporizes—a process called ablation. Tissue is removed by vaporization and superheating of fluids, with associated coagulation and hemostasis.

Tissue Fluorescence

Laser-induced fluorescence is used diagnostically to detect light-reactive substances in tissue, for example in caries detection with devices such as Diagnodent.

Vaporization and Carbonization

At temperatures below 100 °C but above about 60 °C, proteins denature without vaporization. At temperatures above 200 °C, tissue becomes dehydrated and burns, leading to an undesirable effect called carbonization.

2.2 Clinical Applications of the Laser in Dentistry

Laser technology has become an essential tool in dentistry because it can be used to perform various treatments on both soft and hard tissues, offering better control and precision than many traditional techniques. Since the 1990s, clinical advantages such as high precision and significant reduction in postoperative discomfort have made lasers increasingly popular.

Lasers allow precise tissue cutting, minimizing damage to adjacent structures and promoting faster recovery with less inflammation and edema. They can reduce the need for local anesthesia in specific procedures, improving patient comfort by eliminating the vibration and noise associated with traditional dental burs.

In minimally invasive soft and hard tissue surgery, laser use helps reduce intraoperative bleeding and postoperative discomfort, improving overall patient experience. Additionally, lasers provide better visibility of the operative field by maintaining a dry and relatively sterile environment, thereby reducing the risk of postoperative infection and enhancing treatment efficiency.

2.2.1 Temporomandibular Disorders (TMD)

The **temporomandibular joint (TMJ)** is the joint of the jaw that connects the mandible (lower jaw) to the temporal bone of the skull.

Figure2: Temporomandibular Joint (TMJ)

2.2.1.1 Common Causes of TMD

A hormonal component has been suggested, as females are affected more often than males.

Trauma and developmental factors are often initiating causes of TMD.

Rheumatic diseases, such as arthritis, may also contribute to TMJ disorders.

Malocclusion or orthodontic braces may trigger TMD; however, this theory remains disputed and not fully proven.

2.2.1.2 Rationale for Choosing Laser Therapy

Several treatment methods for TMD are available, including painkillers, dental splints, injections, massage, physical therapy, chiropractic treatment, and anti-inflammatory medications. However, these therapies do not always resolve all forms of TMD pain, even after months or years of treatment, because they may not effectively restore the displaced disc.

Conventional methods aim to increase blood supply to affected areas through existing vascular pathways. In TMD, complications often decrease local blood supply, making these therapies less effective. Low level laser therapy (LLLT) uses infrared light at the cellular level to:

Assist blood flow and increase oxygen, glucose, and nutrient delivery to affected muscles

Stimulate the body's own healing processes and speed up recovery

Stimulate collagen production, helping ligaments and tissues grow stronger and faster

Reduce free radicals and oxidative stress

Increase cellular metabolism and significantly reduce pain, while also supporting healing of the nerves surrounding the joint disc

2.2.1.3 Points of Application in TMJ

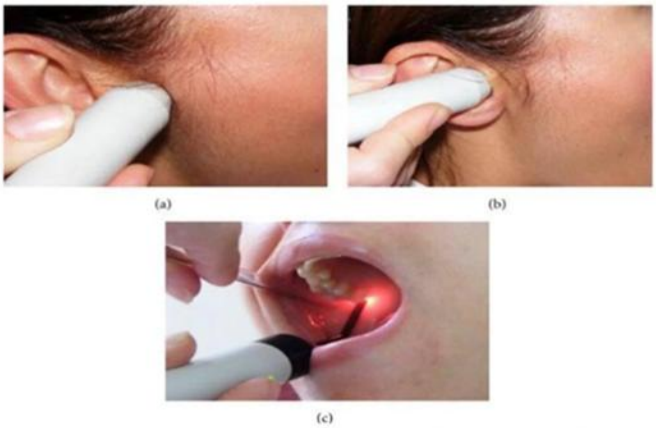
Points of laser application in TMJ therapy include:

The posterior aspect of the joint at maximum opening, targeting the posterior articular branches of the auriculotemporal nerve and the posterior discal attachment, with the beam applied from the anterior region of the external auditory canal.

The same region at maximum opening, but with the beam applied from inside the external auditory canal.

The inferior branches of the medial pterygoid muscle, using a fine fiber-optic probe introduced intraorally through the posterior aspect of the maxillary tuberosity.

These points are illustrated in **Figure 3: Points of application of laser in TMJ**.



Figer3: Points of application of laser in TMJ

2.2.1.4 Reported Benefits of Laser in TMD

Clinical studies have reported several benefits of LLLT in treating TMD, including:

Significant improvement in the number and severity of tender points

Improvement in lateral jaw movement

Increased active and passive maximum mouth opening

Reduction of TMD-related pain, especially chronic pain

Pain control, with lower sensitivity to palpation

Analgesic and anti-inflammatory effects in cases of TMJ arthralgia

Overall reduction in TMD symptoms and improved masticatory efficiency

2.3 Dry Socket (Alveolar Osteitis)

Dry socket is a painful complication following tooth extraction. Normally, a blood clot forms in the socket, protecting the underlying bone and nerve endings. If this blood clot is dislodged or fails to form properly, the bone and nerve remain exposed, causing severe pain and increasing the risk of infection. **Figure 4** illustrates a typical dry socket.

Figure4: Dry socket

2.3.1 Causes of Dry Socket

Trauma: Difficult or traumatic extractions enhance fibrinolytic activity, leading to disintegration of the blood clot.

Infection: Pre-existing or postoperative infection (e.g., extraction of a tooth with pericoronitis) predisposes to dry socket.

Local Anesthesia: Use of vasoconstrictor-containing anesthetics may decrease local blood supply, increasing dry socket risk.

Dense, poorly vascularized bone is more susceptible.

Post-extraction sucking or spitting can create negative pressure, detaching the blood clot from the alveolar bone.

Remaining root fragments or foreign bodies in the socket.

Systemic factors such as anemia, diabetes mellitus, and tuberculosis.

2.3.2 Treatment with Laser

High doses of laser energy are useful for reducing postoperative pain; however, for optimal healing, lower power with longer exposure times is more advantageous. The main goal of LLLT after extraction is to stimulate fibroblasts to seal the socket.

In cases of dry socket, traditional management (e.g., curettage and medicated dressing) is combined with high doses of LLLT to reduce patient discomfort. When the dressing is changed at subsequent appointments, lower doses are applied to stimulate fibroblast growth.

LLLT not only stimulates fibroblast proliferation but also promotes parallel arrangement of collagen bundles, resulting in a smoother tissue surface, which is especially beneficial in extraoral surgery where cosmetic results are important. **Figure 5** shows treatment of dry socket using laser.

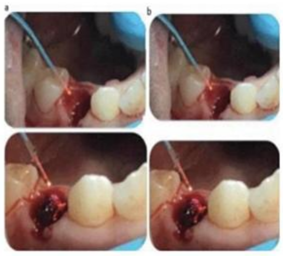


Figure5: Treatment of dry socket with Laser

2.4 Mucoceles

Mucoceles are non-neoplastic cyst-like lesions of minor or major salivary glands resulting from mucus accumulation. They are often described as "mucus-filled cavities" and are usually found in the oral cavity, lacrimal sac, or paranasal sinuses. These lesions are most common in children.

Although conventional treatment involves local surgical excision, diode laser excision (e.g., 940 nm) is often preferred to reduce intraoperative bleeding and edema and to promote better healing.

2.4.1 Laser Treatment of Mucoceles

In a reported case, mucocele removal with a diode laser was performed as follows:

The laser tip was directed toward the lip surface at the base of the lesion at an angle of 10–15°.

Circular movements were carried out around the base while the mucocele was held with tweezers.

The site was continuously mopped with sterile wet gauze to avoid overheating.

The tip was regularly checked and cleaned with sterile gauze to remove debris or damage.

The mucocele was completely removed in about 5 minutes. No bleeding occurred at the surgical site, and no sutures were required. **Figure 6** illustrates mucocele treatment with laser.

Figure6: Treatment of Mucoceles with laser

2.5 Ranulas

Ranulas are mucus extravasation phenomena that occur after trauma to the sublingual gland or due to mucus retention from obstruction of the sublingual ducts. They appear as bluish, fluctuant swellings in the floor of the mouth, as shown in **Figure 7**.

Figure7: Ranulas cause obstruction of the sublingual ducts.

2.5.1 Laser Treatment of Ranulas

Treatment options include marsupialization with or without packing, excision of the ranula with or without removal of the sublingual gland, and laser excision or vaporization. Carbon dioxide laser excision has been reported as a safe method with minimal or no recurrence, providing precise removal and good hemostasis. **Figure 8** demonstrates CO_2 laser excision of a ranula.

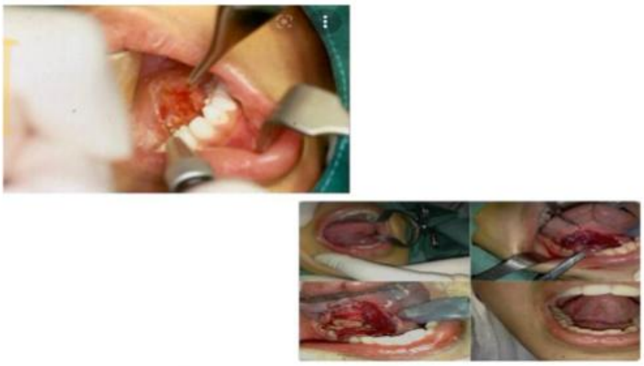


Figure8: Carbon dioxide laser excision of ranula

2.6 Oral Leukoplakia

Oral leukoplakia is a potentially malignant disorder, defined as a white plaque of the oral mucosa that cannot be characterized as any other definable disease and carries an increased risk of malignant transformation. It is a relatively common lesion that may precede squamous cell carcinoma, although most lesions are asymptomatic. The clinical site and the presence of epithelial dysplasia are major factors in malignant potential.

2.6.1 Removal of Oral Leukoplakia with Laser

Treatment options for oral leukoplakia include conventional surgical excision, topical or systemic medications, laser surgery, and conservative management. Studies indicate that CO_2 lasers are effective for treating oral mucosal lesions.

Soft tissue can be removed by superficial ablation with minimal thermal damage to surrounding tissues, resulting in minimal scarring, low postoperative pain, and limited edema. **Figure 9** shows treatment of oral leukoplakia using a CO_2 laser.

Figure9: Treatment of oral leukoplakia with CO2 laser

2.7 Oral Lichen Planus

Oral lichen planus (OLP) is a chronic mucocutaneous disease of uncertain etiology. Because the cause is unknown, there is no single standard therapy. Conventional treatment relies mainly on topical or systemic corticosteroids.

Advances in laser technology have introduced new therapeutic options for diseases refractory to conventional treatment. Previous studies have used CO_2, Nd:YAG, excimer, and various diode laser wavelengths to manage different forms of lichen planus.

Laser therapy has been suggested as an alternative treatment modality with minimal side effects. Case reports describe low level laser therapy as effective in erosive or ulcerative OLP that had not received prior treatment, with good clinical response and no reported complications. **Figure 10** shows erosive/ulcerative OLP.

Figure10: Erosive/ulcerative oral lichen planus.

2.8 Gingival Melanin Pigmentation

Melanin is a brown pigment located in the basal and suprabasal layers of the gingival epithelium. It plays a principal role in physiologic gingival pigmentation. The degree of pigmentation is also influenced by epithelial thickness, blood vessel distribution, and degree of keratinization.

Physiologic gingival pigmentation is largely genetically determined; however, other factors such as endocrine activity, ultraviolet radiation, smoking, and certain medications can contribute to gingival hyperpigmentation. This condition may present a significant aesthetic concern, especially in the anterior maxillary and mandibular gingiva.

Several techniques have been used for gingival depigmentation, including rotary instruments, scalpel surgery, electrosurgery, and different types of lasers. In addition to CO_2 and erbium:YAG lasers, diode lasers with various wavelengths have been widely employed, generally without major side effects. **Figure 11** shows gingival melanin depigmentation using a CO_2 laser.

Figure11: Gingival melanin depigmentation by using carbon dioxide laser.

Chapter Three: Effectiveness of Various Laser Types in the Treatment

Dental lasers can be categorized into two major groups based on output power:

Low output power (Low-Level) lasers

Helium–Neon (He–Ne) laser

Diode laser

Medium output power lasers

Carbon dioxide (CO_2) laser

Neodymium:Yttrium–Aluminum–Garnet (Nd:YAG) laser

Erbium family lasers (Er:YAG, Er,Cr:YSGG)

These systems differ in wavelength, absorption characteristics, and biological effects, which determine their suitability for specific dental procedures. The following sections describe each type in detail.

3.1 Helium–Neon (He–Ne) Laser

The He–Ne laser emits light at 632.8 nm and is classified as a low level laser therapy (LLLT) device. Although its exact mechanism is not completely understood, physiological studies suggest that He–Ne laser irradiation can influence cellular electrical activity without directly stimulating A-delta or C-fiber nociceptors.

He–Ne laser energy enhances cellular metabolism, microcirculation, and mitochondrial ATP production, leading to accelerated tissue regeneration and modulation of pain. It is particularly used in photobiomodulation for:

Aphthous ulcer healing

Pain management in temporomandibular joint disorders

Post-herpetic neuralgia

Clinical studies report treatment effectiveness ranging between 50–100%, depending on dosage parameters and tissue type. Repeated He–Ne laser sessions have been shown to enhance fibroblast proliferation and collagen remodeling, promoting faster mucosal healing.

3.2 Diode Laser

The diode laser, operating in the 655–980 nm range, uses a semiconductor active medium and generates photons through electrical excitation. It is compact, energy-efficient, and widely used in dentistry.

Clinical applications include:

Frenectomy

Fibroma excision

Gingival depigmentation

Photocoagulation of vascular lesions

Removal of hyperplastic tissue

Key advantages of diode lasers:

Nearly bloodless surgical field and excellent hemostasis

Reduced postoperative swelling, pain, and scarring

Minimal anesthesia required in most procedures

Short healing times with decreased risk of bacterial infection

Clinical cases, such as pyogenic granuloma removal and gingival hyperpigmentation correction, have shown effectiveness rates between **53.3% and 94.2%**. Modern diode units offer both contact and non-contact tips, improving surgical precision and control. **Figure 13** illustrates hyperpigmented gingiva treated with a 940 nm diode laser.

Figure 13. Hyperpigmentation of gingiva treated with 940 nm Diode laser

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3.3 Carbon Dioxide (CO_2) Laser

The CO_2 laser operates at 10,600 nm, emitting infrared light that is strongly absorbed by water molecules. This property allows precise ablation of soft tissues with simultaneous coagulation, making it ideal for many mucosal surgeries and lesion excisions.

Clinical uses in dentistry include:

Removal of soft tissue lesions such as leukoplakia, fibroma, and papilloma

Gingival recontouring and frenectomy

Treatment of dentin hypersensitivity by partial occlusion of dentinal tubules and reduction of permeability

Although no direct nerve analgesic effect has been demonstrated, the decreased dentinal permeability reduces sensitivity. Reported effectiveness ranges from **59.8% to 100%**, with significant reduction in bleeding, swelling, and postoperative pain.

Advanced super-pulsed CO_2 systems further minimize collateral thermal damage. **Figure 14** shows lesion excision with a CO_2 laser, demonstrating clear surgical margins.

Figure 14: Lesion excision performed using CO_2 laser demonstrating a clear surgical margin.

3.4 Nd:YAG Laser (Neodymium–Yttrium–Aluminum–Garnet)

The Nd:YAG laser emits light at 1,064 nm and penetrates deeper into tissue compared with CO_2 and diode lasers. It has strong affinity for pigmented tissues and hemoglobin, allowing deep coagulation and effective bacterial reduction.

In treating dentin hypersensitivity, the Nd:YAG laser works by:

Occluding dentinal tubules through localized melting and recrystallization of peritubular dentin

Producing direct analgesic effects on nerve fibers

Due to its deep penetration, clinicians often apply black ink or carbon-based absorbers on the surface to prevent excessive thermal effects in the pulp.

Reported treatment effectiveness ranges from **5.2% to 100%**, depending on exposure time and laser parameters. Nd:YAG lasers are also used for:

Periodontal pocket decontamination

Gingival depigmentation

Pain control in temporomandibular disorders

Figure 15 shows a pyogenic granuloma of the gingiva treated with an Nd:YAG laser, demonstrating complete lesion ablation.

Figure 15

3.5 Erbium Family Lasers

3.5.1 Er:YAG Laser

The Er:YAG laser operates at 2,940 nm and is strongly absorbed by water and hydroxyapatite. This makes it highly suitable for:

Caries removal

Cavity preparation

Bone reshaping and osteotomy

For safety, the laser tip should generally be positioned about 10 mm or more away from the target surface to avoid overheating. In controlled clinical trials, treatment effectiveness after six months ranged between **38.2% and 47%**, influenced by surface moisture and operator technique.

Recent evidence also confirms its usefulness in reducing dentinal hypersensitivity and removing biofilm, making it a promising tool in restorative and preventive dentistry.

.5.2 Er,Cr:YSGG Laser

The Er,Cr:YSGG (Erbium–Chromium:Yttrium–Scandium–Gallium–Garnet) laser emits at 2,780 nm and has a slightly higher penetration depth than Er:YAG. It is effective in both hard and soft tissue procedures, such as:

Enamel cutting

Gingivectomy

Osseous contouring

A single treatment session can significantly reduce dentinal hypersensitivity compared to placebo, with effects remaining stable for at least three months. Er,Cr:YSGG lasers produce a micro-explosive photoacoustic effect that enables non-contact cutting with less vibration and better patient comfort. **Figure 16** shows enamel surface etched with Er,Cr:YSGG laser, revealing a micro-retentive pattern suitable for bonding.

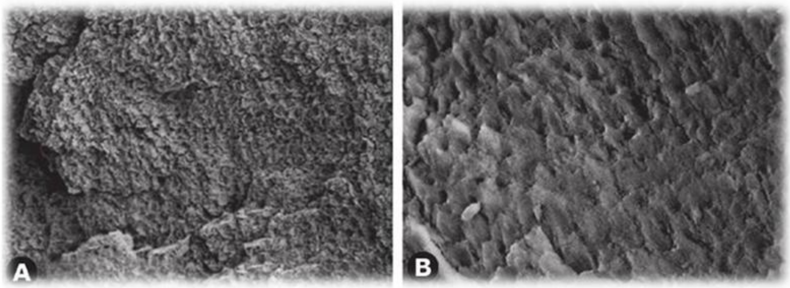

Figure 16: Enamel surface etched with Er,Cr:YSGG laser showing micro-retentive pattern suitable for bonding.

3.6 WaterLase Technology

WaterLase is one of the most advanced developments in dental laser systems. It combines focused erbium laser energy with a fine water mist, producing a **hydrokinetic cutting** effect.

This system allows:

Nearly pain-free, often anesthesia-free treatment for many procedures involving enamel, dentin, bone, and soft tissues

Biological micro-ablation with excellent precision, as the laser energizes water molecules in both the spray and target tissue

Figure 17: WaterLase device used for soft tissue and caries removal procedures.

3.6.1 Benefits of WaterLase

Faster healing and less trauma to teeth and gingiva

Reduced need for anesthetic agents in most treatments

Ability to treat multiple areas of the mouth in a single session

Lower risk of cross-contamination due to non-contact technique

Enhanced patient comfort and reduced anxiety, particularly in pediatric patients

3.6.2 Uses of WaterLase in Dentistry

Smile enhancement: Gingival contouring and removal of excess tissue in "gummy smile" cases.

Oral growth removal: Safe, efficient excision of fibromas and soft tissue covering unerupted teeth.

Tongue-tie correction: Precise frenectomy with minimal bleeding, often without sutures or significant postoperative discomfort.

Gum recession prevention: Reduced inflammation and improved gingival reattachment.

Periodontal therapy: Cleaning periodontal pockets, preserving bone, and disinfecting root surfaces, especially when combined with adjunctive medications.

Chapter Four: Conclusions

Based on all reviewed studies and clinical data, several conclusions can be drawn regarding the role of laser technology in dentistry:

The use of laser systems in dentistry is highly beneficial for both hard and soft tissue treatments, offering improved precision, faster healing, and minimal discomfort. Lasers are also effective as therapeutic tools in tissue management and wound healing.

Diode laser applications are particularly advantageous because of their safety, efficiency, and good patient acceptance. They are well tolerated by pediatric and anxious patients, providing relatively painless procedures and rapid recovery with few postoperative complications.

Current scientific literature still lacks sufficient large-scale, high-quality randomized clinical trials with standardized sample sizes and long-term follow-up. More studies are required to generate stronger evidence, especially for pediatric oral pathologies such as ranulas.

Integration of laser therapy into modern dental practice has transformed traditional treatment approaches. Lasers complement existing procedures, improving patient satisfaction, surgical precision, and postoperative management.

CO_2 lasers remain a **gold standard** for soft tissue benign lesion excision, demonstrating lower recurrence rates, superior hemostasis, and fewer complications compared with scalpel or electrosurgical techniques. They should be routinely considered in clinical protocols.

Low level laser therapy (LLLT) continues to gain importance as an adjunctive modality for controlling postoperative pain, managing dry socket, and enhancing tissue healing in general dental practice.

Despite these advantages, laser energy carries inherent risks, including potential thermal damage to tissues and risk of eye injury. Therefore, strict adherence to laser safety protocols, appropriate training, and regular device calibration are essential to ensure safety for both patients and clinicians.

In conclusion, dental lasers are indispensable in advancing minimally invasive dentistry. With adequate clinical training, proper parameter selection, and continued research, their use is expected to expand further, shaping the future of precise, pain-reduced, and biologically compatible dental care.

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