LASER IN DENTISTRY

A Review Article

Submitted to the college of dentistry, Babylon University

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ وَأَن لَّيْسَ لِلْإِنسَانِ إِلَّا مَا سَعَى 39 وَأَنَّ سَعْيَهُ

سَوْفَ يُرَى 40 ثُمَّ يُجْزَاهُ الْجَزَاءَ الْأَوْفَى 41 ﴾

صدق الله العلي العظيم

(آيه 39-41)

الإهداء

اليك يا أمي يا من علمتني العطاء دون إنتظار المقابل، يامن زرعتي في قلبي أسمى معاني الافاضل

إلى ذلك الصرح العظيم الدي علمني الخلق الكريم ، والدي صاحب الفضل الكبير

إليك يا استاذي الكريم الذي علمتني أن تشجيع المعلم لتلميذه دافع قوي على التقدم

الى إخوتي وأخواتي سندي في حياتي ؛ وإلى جميع الاخوة الذين اثبتو ان الاخوة ليست فقط في الرحم

إلى كل من دعمني وشجعني في حياتي وأعطاني دفعة نحو الامام

Abstract:

This review collected from the literature on the usage of laser in dentistry based on the medical studies in the time period between the years: 2000 and 2022, where the most up to date indications of laser in dentistry are intended to be reviewed .

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

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CHAPTER ONE

1.1: Introduction

The term LASER is an acronym for 'Light Amplification by the Stimulated Emission of Radiation'. As its first application in dentistry by Miaman, in 1960, the laser has seen various hard and soft tissue applications. In the last two decades, there has been an explosion of research studies in laser application [(1)].

In hard tissue application, the laser is used for caries prevention, bleaching, restorative removal and curing, cavity preparation, dentinal hypersensitivity, growth modulation and for diagnostic purposes, whereas soft tissue application includes wound healing, removal of hyperplastic tissue to uncovering of impacted or partially erupted tooth, photodynamic therapy for malignancies, photo-stimulation of herpetic lesion [(2)].

Laser is a monochromatic, collimated, coherent, and intense beam of light produced by stimulated emission of radiation of a light source. Lasers are classified according to different factors among which is the classification based on laser active medium such as gas, liquid, solid and semi-conductor, which identifies and distinguishes the type of emitted laser beam [(2)].

Visible beams (i.e. the Argon laser at 488 or 518 nm) and invisible beams in the infrared range (i.e. CO_2 (Carbon Dioxide Laser), Ho:YAG (Holmium Yttrium Aluminium Garnet), Er:YAG (Erbium substituted:Yttrium Aluminium Garnet), Er-Cr: YSGG (Erbium, Chromium Doped Yttrium Scandium Gallium Garnet), ND:YAG (Neodymium-Doped Yttrium Aluminium Garnet), Diode (Gallium Arsenide) (GaAa)) are used in dentistry. The properties of a specific laser

beam, particularly wavelength and the optical characteristics of the particular target tissue determine the type and the extent of interaction which may occur[1]. Low level laser therapy (LLLT) which has therapeutic effects without inducing a lot of heat is established in clinical dentistry because of its anti-inflammatory, bio stimulant and regenerative effects. Its use has been widely reported with satisfactory results in the literature [(2)].

1.2: Aim of 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 in dentistry can be summarized by the following points [3]:

- No need for anesthesia with some procedures.
- Reduced risk of bacterial infections – the use of lasers sterilizes the area as it treats.
- Decreased need for sutures with some procedures.
- Minimal bleeding as the laser promotes blood clotting.
- Faster healing times.
- Less post-procedure pain and swelling.
- Less damage to the surrounding tissue – the focused light produced by lasers allow the dentist to focus on damaged tissue while leaving healthy tissue untouched
- Reduced anxiety and increased comfort.
- Reduced need for medications and antibiotics after treatment.

1.4: Disadvantages of laser

- Lasers can't be used to fill cavities located between teeth, around old fillings, and large cavities that need to be prepared for a crown. In addition, lasers cannot be used to remove defective crowns or silver fillings, or prepare teeth for bridges.
- Traditional drills may still be needed to shape the filling, adjust the bite, and polish the filling even when a laser is used.
- Lasers do not eliminate the need for anesthesia.
- Laser treatment are more expensive since the cost of the laser is much higher than a dental drill [4].

1.5: Applications of Laser

1.5.1: Soft Tissue Application:

- Wound healing.
- Post herpetic neuralgia and apthous ulcer.
- Photodynamic therapy for malignancies.
- Aesthetic gingival re-contouring and crown lengthening.
- Exposure of unerupted and partially erupted teeth.
- Frenectomies [5].

1.5.2: Hard Tissue Application[6]:

- Cavity preparation, caries, and restorative removal.
- Treatment of dentinal hypersensitivity.
- Diagnostic application.
- 3-D Laser scanner for e-model preparation.

1.6: Laser safety

While most dental lasers are relatively simple to use, certain precautions should be taken to ensure their safe and effective operation. First and foremost is protective eyewear by anyone in the vicinity of the laser, while it is in use. This includes the doctor, chair side assistants, patient, and any observers such as family or friends. It is critical that all protective eyewear worn is wavelength-specific. Additionally, accidental exposure to the non-target tissue can be prevented through the use of warning signs posted outside the nominal hazard zone, limiting access to the surgical environment, minimizing the reflective surfaces, and ensuring that the laser is in good working order, with all manufacturer safeguards in place. With regard to prevention of possible exposure to infectious pathogens, high volume suction should be used to evacuate any vapor plume created during tissue ablation, and normal infection protocols should be followed. Each office should have a designated Laser Safety Officer to supervise the proper use of the laser and coordinate staff training .[7]

CHAPTER TWO

2. Application of Laser in Dentistry

2.1: Laser with sensitivity

A specific condition that is defined as pain arising from exposed dentin. The pain is brief, sharp, well-localized in response to thermal, evaporative, tactile, osmotic, or chemical stimuli which cannot be referred to any other form of dental defect or pathology. It's affecting more than 40% of adults worldwide. The cervical area of teeth is the most common site of hypersensitivity [8].

2.1.1: Etiology and Predisposing Factors

1- Attrition: is mechanical wear of the incisal or occlusal surface usually associated with occlusal functions.

2- Abrasion: is abnormal tooth surface loss resulting from direct friction forces between the teeth and the external objects &Tooth brushing.

3- Erosion: is the wear or loss of tooth surface by chemico-mechanical action. Exposure to non-bacterial acids in the diet, chemical product [9].

4- Abfraction wedge-shaped defects is aheavy eccentric occlusal force.

5- Bleaching: Post-dental bleaching sensitivity.

6- Periodontal Treatment: the removal of supra and/or subgingival calculi.

7- Gingival recession, Physiological Causes [10].

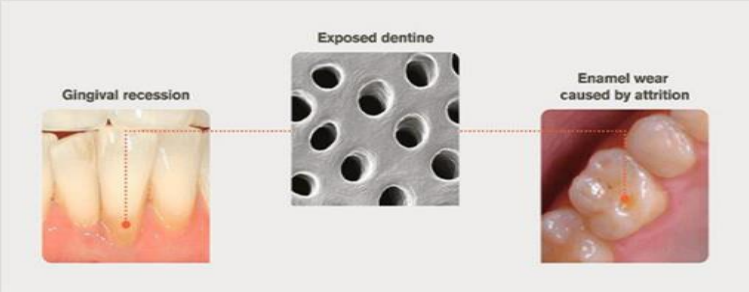


Figure1: tooth wear microscopically

2.1.2: Mechanism of Laser Treatment:

The mechanisms involved in laser treatment of dentine hypersensitivity are relatively unknown [11]. By interacting with the tissue, causes different tissue reactions, according to its active medium, wavelength and power density and to the optical properties of the target tissue. There is suggestion that it may occur through coagulation and protein precipitation of the plasma in the dentinal fluid or by alteration of the nerve fiber activity [12].

2.2: The Temporomandibular Joint (TMJ)

Is the joint of the jaw and connects the lower jawbone or mandible to the upper temporal bone which is part of the cranium (skull). [13]

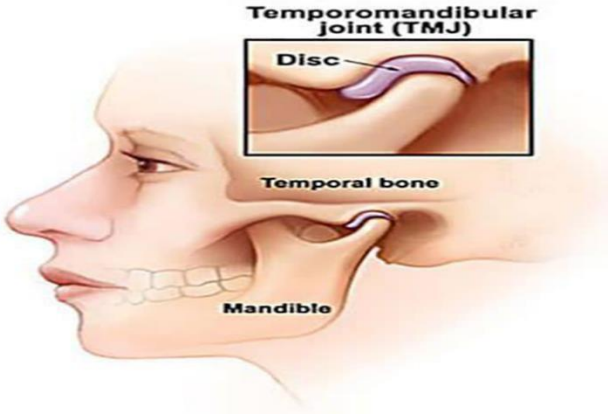


Figure2: Temporomandibular Joint (TMJ)

2.2.1: The most common causes of TMD

1. Scientists assume that a female hormone may be the cause of TMJ Disorder since females are more affected than men.

2. trauma and development factors are typically the initial factors of TMD.

3. rheumatic disease, such as arthritis, may also be the cause of TMJ Disorders.

4. bad bite or orthodontic braces can trigger TMJ disorders. But this theory is disputed by the researches and is of course not proven. (14)

2.2.2: The causes for choose laser

There are several treatment methods available. Some such typical treatments are pain killers, dental splints, injections, massages, physical therapy, chiropractic or anti-inflammatory medications. But unfortunately, these therapies work for some but don't always resolve all the various form of TMJ pain for everyone, even after months and years of various treatment forms. This is because these therapies are not very successful to restore the displaced disk. The typical methods try to send blood to the affected areas and rely on available paths to send blood. If adequate amount of blood can be supplied, the muscles and other affected parts will get energy and be healed. But TMD complications often decrease blood supply to the affected areas. So, typical therapies are often not very effective. (15)

- LLLT uses infra-red-light therapy at a cellular level
- Laser therapy assists blood flow thus increasing oxygen, glucose and nutrients supplied to the affected muscles
- Stimulates the body's own healing process and speeds up recovery Time.(16)

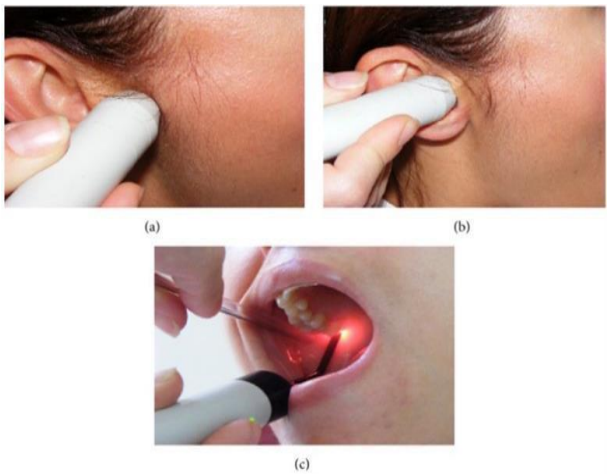
- The protons stimulate collagen production, aiding ligaments and tissues to grow stronger, faster
- Reduces free radicals and oxidative stress
- increases cell metabolism and greatly reduces pain. also healing the nerves surrounding the jaw disk.

2.2.3: Points of application in TMJ

(a) the posterior aspect of the joint in maximum opening to treat the posterior articular branches of the auriculotemporal nerve and posterior discal attachment region by applying the beam from the anterior of the external auditory channel

(b) same region in maximum opening from inside the external auditory channel

(c) to the inferior branches of the medial pterygoid muscle with the fine fiber optic probe of the device from inside the mouth through the posterior of the tuber maxilla.[16]



Figer3: Points of application of laser in TMJ

2.2.4: Several benefits were found such as

- a number of tender points were significantly improved.
- lateral motion.
- active and passive maximum mouth opening [17] .
- TMD- related pain, especially long lasting pain [18].
- pain control, especially lower sensitivity to palpation [19].
- in arthralgia, the analgesic and anti-inflammatory effects were achieved [20].
- reducing TMD symptoms, and has influence over masticatory efficiency [21].

2.3: Dry socket

Dry socket, also called alveolar osteitis, is a painful complication of a tooth extraction. When a tooth is pulled, a blood clot usually forms in the socket. This blood clot protects the bone and nerve. If the blood clot is dislodged or does not form well, the bone and nerve are left exposed. This causes extreme pain and can lead to infection. [22]

Figure4: Dry socket

2.3.1: Causes of dry socket

1. Trauma: Traumatic procedure and difficult extraction will enhance the fibrinolytic activity which lead to disintegration of the blood clot.
2. Infection: during or after or before the extraction of the tooth may predispose for the dry socket such as extraction of a tooth associated with pericoronitis may leads to a dry socket.
3. Local anesthesia: There is a positive correlation between the amount of local anesthesia and dry socket due to the effect of the vasoconstrictors which decrease the blood supply.
4. Dense bone that has a poor vascularity more susceptible for dry socket.
5. Post extraction sucking or spiting which produce a negative pressure resulting in the detachments of the blood clot from the alveolar bone and development of dry socket.
6. Remaining root or foreign body in the alveolus.
7. General factors such as anemia, diabetes mellitus, T.B [23].

2.3.2: Treatment with Laser

High doses of laser energy can focus on the postoperative pain, but to obtain a good healing process, lower power and longer time are more advantageous.

The major goal of LLLT after extractions is to stimulate the fibroblasts to seal the socket. In cases of failure (dry socket), the traditional methods are used in combination with high doses of LLLT to reduce patient discomfort. When the dressing is changed during subsequent appointments, lower doses are given to stimulate fibroblast growth. Not only does LLLT stimulate

fibroblast proliferation, but the cells are arranged in parallel bundles as well, creating a smoother area. This is of particular interest in extraoral surgery when the cosmetic aspect is important [24].

Figure5: Treatment of dry socket with Laser

2.4: Mucoceles

Mucoceles are nonneoplastic cystic lesions of major and minor salivary glands which result from the accumulation of mucus.

Mucoceles are known as “mucus filled cavities” usually present in the oral cavity, lacrimal sac, and paranasal sinuses [25].

These lesions are most commonly seen in children. Though usually these lesions can be treated by local surgical excision, to avoid intraoperative surgical complications like bleeding and edema and to enable better healing, excision was preferred using a diode laser in the wavelength of 940 nm [26] .

2.4.1: Treatment

In a case report, the treatment plan consisted on mucocele removal with laser application. The tip was directed to the surface of the lip at the base of the lesion at an angle of 10 to 15°. Movements were performed around the base, while the mucocele was grabbed by tweezers. The site was slowly and continuously mopped by sterile wet gauze to avoid tissues overheating. Care was taken also to always control the tip. If upon inspection, any damage or collection of debris was observed during treatment, the tip was cleaned with a sterile gauze. The mucocele was totally removed in 5 minutes. No bleeding was observed in the operative site and no sutures were necessary [27].

Figure6: Treatment of Mucoceles with laser

2.5: Ranulas

Ranulas are mucus extravasation phenomenon formed after trauma to the sublingual gland or mucus retention from the obstruction of the sublingual ducts. [28]

Figure7: Ranulas cause obstruction of the sublingual ducts.

2.5.1: Treatment

There are various methods for treating ranulas, including marsupialization with or without open packing, excision of ranula with or without removal of sublingual gland, and laser excision and vaporization of ranula [28] · Carbon dioxide laser excision of ranula is safe with minimal or no recurrence.

Figure8: Carbon dioxide laser excision of ranula

2.6: Pyogenic granuloma

Pyogenic granuloma is a 'reactive lesion' in the oral cavity caused due to hormonal imbalance or poor oral hygiene. There are different methods to excise this lesion but most successful is treatment with lasers [29].

2.6.1: Treatment:

Currently, there are different lasers available commercially and are used by clinicians to excise this lesion. The patient reported no pain, no blood loss during or postsurgery. Laser is a useful technique for excisional surgeries; it is safe, effective and reduces time of treatment as well as time of healing [29] . In a case report, The lesion was treated by Soft-tissue Diode Laser manufactured by Picasso (Kavo, USA), with following specifications: wavelength 808 nm (± 10), output energy 0.1–7.0 W, and input power 300 VA. Local anaesthesia was not used. The tip was kept at a distance of about 1 mm from the soft tissue throughout the procedure, and it took 4–5 min to completely excise the mass. The diode laser provided an optimum combination of clean cutting of the tissue and haemostasis. Patient was not prescribed any antibiotics, analgesics, or anti-inflammatory medication and was subjected to routine scaling and curettage [30].

Figure9: Treatment Pyogenic granuloma with lasers

2.7: Benign oral soft tissue lesion

There is a wide range of oral soft tissue benign lesions, most of them amenable to surgical resection. Various modalities of Surgical resection are available including cold surgical resection, Cryo surgery and Laser resection[31].

2.7.1:Treatment:

Laser resection is an ideal means of treatment of oral soft tissue benign lesions. Carbon dioxide laser is the most commonly used laser for surgical excision of oral soft tissue benign lesions [32].

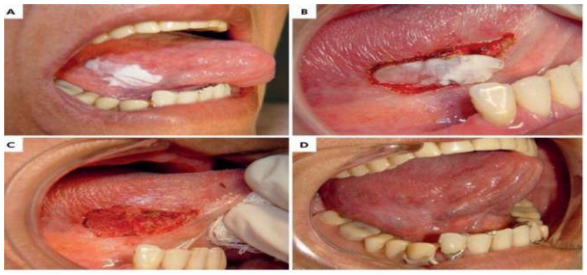


Figure10: Laser resection of Benign oral soft tissue lesion

2.8: Oral leukoplakia

Oral leukoplakia is a potentially malignant disorder, defined as a white plaque that cannot be diagnosed as another known disease or disorder, and has an increased risk of malignancy. [33]

Leukoplakia is a relatively common oral lesion that may precede the development of squamous cell carcinoma, although most lesions are asymptomatic. The clinical location and presence of epithelial dysplasia are factors that may increase the incidence of malignant transformations.

2.8.1: Removal of Oral leukoplakia

Treatment of oral leukoplakia consists of conventional surgical excision, topical and systemic medication, laser surgery, and even conservative approaches. [34]

Studies have shown that CO_2 laser is an effective instrument for the treatment of lesions of the oral mucosa. Soft tissues can be removed by superficial ablation with minimal thermal damage to adjacent tissues, resulting in minimal scarring and

little postoperative pain and edema.

Figure11: Treatment of oral leukoplakia with CO2 laser

2.9: Oral lichen planus

Oral lichen planus (OLP) is a mucocutaneous disease with uncertain etiology. As the etiology is unknown standard treatment modalities are not available. The traditional and common treatment relies on corticosteroids whether topical or systemic. In recent years, development of lasers made a proper path to use this instrument for treatment of the diseases which are refractory to conventional treatments. Previous studies in this field used CO2, ND:YAG, Excimer and some wavelength of diode lasers for the treatment of different types of lichen planus. [35]

Laser therapy has recently been suggested as a new treatment option without significant side effects. An article presents two cases of erosive/ ulcerative oral lichen planus, who had not received any treatment before. Low Level Laser Therapy was an effective treatment with no side effects and it may be considered as an alternative therapy for erosive/ulcerative oral lichen planus. [36]

Figure12: Erosive/ulcerative oral lichen planus.

2.10: Gingival melanin pigmentation:

Melanin is a brown pigment, located in basal and suprabasal layers of gingival epithelium. It plays a main role in physiologic gingival pigmentation which is also determined by the thickness of epithelium, presence of blood vessels, and epithelium keratinization degree. Physiologic pigmentation is mainly genetically determined; however, some other factors such as activity of endocrine glands, ultraviolet radiation, smoking, and medication can also cause gingival hyperpigmentation. It is a real esthetic concern for most of the individuals, especially in the anterior keratinized gingiva of the maxilla and mandible. [37]

For depigmentation of gingiva, different techniques have been used such as rotary instruments, scalpel technique, electro surgery, and different types of lasers. In addition to carbon dioxide and erbium: yttrium– aluminum–garnet

lasers, diode lasers with different wavelengths have also been commonly used with no side effects. (38)

Figure12: Gingival melanin depigmentation by using carbon dioxide laser.

CHAPTER THREE

3: Effectiveness of various laser types in the treatment:-

The lasers used for the treatment are divided into two groups:

Low output power (low-level) lasers :-

- (He- Ne) helium-neon
- Diode lasers

Middle output power :-

- Carbon Dioxide Laser (CO_2)
- Nd:YAG
- and the Erbium family Er:YAG - Er,Cr:YSGG lasers [39]

3.1: He-Ne laser:

The mechanism involved is mostly unknown. According to physiological experiments, He-Ne laser irradiation does not affect peripheral Adelta or C-fiber nociceptors, but does affect electric activity. Treatment effectiveness rates of He-Ne laser ranges from 5.2%– 100% based on different studies[40]

3.2: diode laser

Diode laser is one of laser systems in which photons are produced by electric current with wavelengths of 655- 980nm. The application of diode laser in soft tissue oral surgery has been evaluated from a safety point of view, for facial pigmentation and vascular lesions and in oral surgery excision; for example frenectomy, epulis fissuratum and fibroma.

The advantages of laser application are:- that it provides relatively bloodless surgical and post surgical courses with minimal swelling and scarring. We

used diode laser for excisional biopsy of pyogenic granuloma and gingival pigmentation. effectiveness rates range from 53.3%–94.2%

Figure13: hyperpigmentation of gingiva laser therapy by Diode laser

3.3: CO_2 Laser

With wavelengths of 10600nm effects on dentin hypersensitivity are due to the occlusion or narrowing of dentinal tubules. There have been no reports on nerve analgesia by CO_2 laser irradiation. Using the CO_2 laser at moderate energy densities, mainly sealing of dentinal tubules is achieved, as well as a reduction of permeability. Treatment effectiveness ranges from 59.8 to 100%

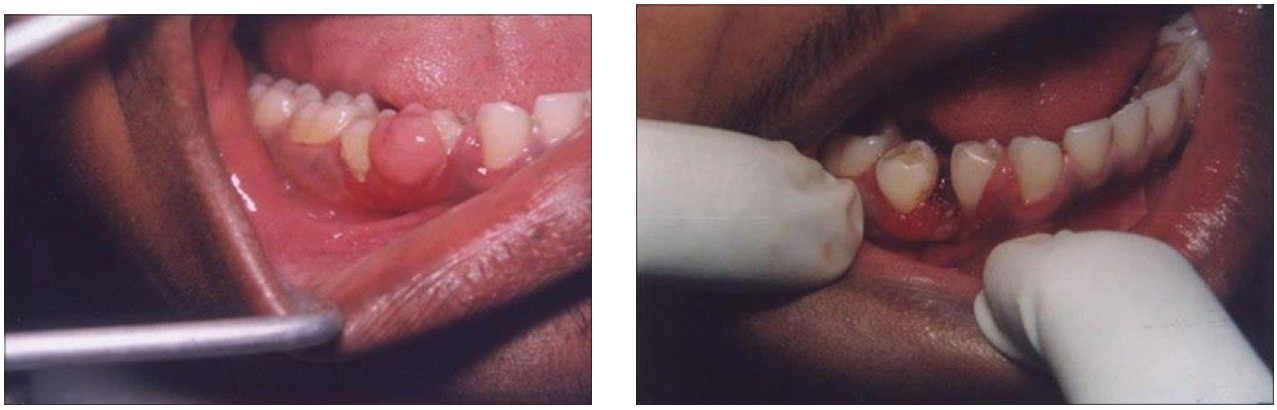


Figure14: lesion Excision by use of CO_2 Laser

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

With wavelengths of 1064nm. effects on dentine hypersensitivity is thought to be the laser-induced occlusion or narrowing of dentinal tubules. As well as direct nerve analgesia .to prevent deep penetration of the Nd:YAG laser beam through the enamel and dentin and excessive effects in the pulp use of black ink as an absorption enhancer is recommended. Treatment effectiveness ranged from 5.2 to 100%.

Figure15: Pyogenic granuloma gingiva laser therapy by using ND:YAG laser

3.5: Erbium family Laser

3.5.1: Er :YAG Laser

Suitable for caries treatment but endodontic and periodontic applications have also been studied. In order to prevent damage to the tooth and gingival surface, with wavelengths of 2940nm. The distance of the laser tip to tooth surface has to be kept more than 10 cm. Treatment effectiveness in 6 months ranges from 38.2%–47%

3.5.2: Er, Cr:YSGG Lasers :- (erbium chromium: yttrium)

with wavelengths 2780nm effective for soft-tissue surgery as well as for cutting enamel, dentine and bone. the single application laser has shown efficacy in rapid dentin hypersensitivity reduction compared with placebo

treatment. This effect has become apparent immediately, and it remained stable for a 3-month examination period [41]

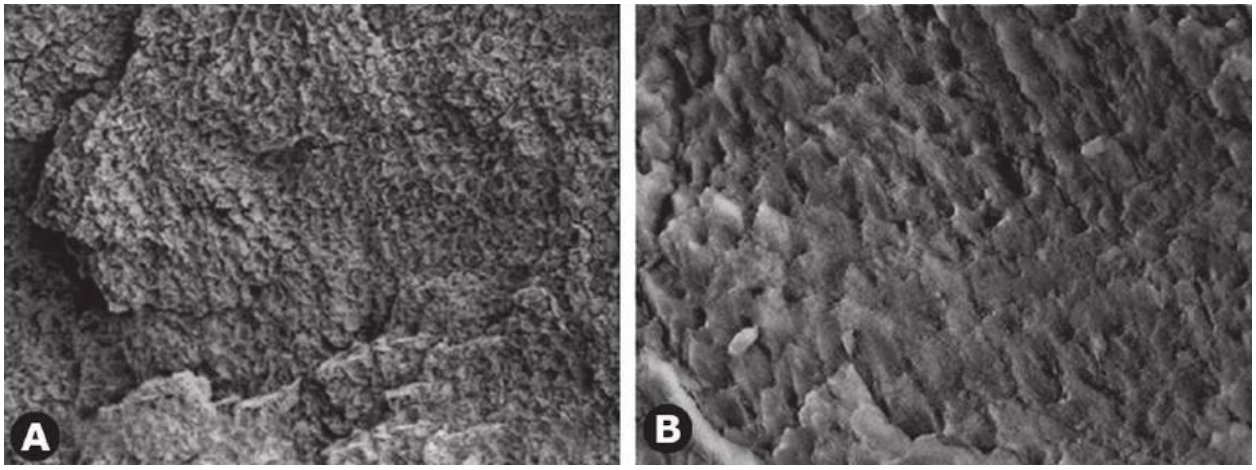


Figure16: Enamel surface etched with Er ,Cr:YSGG laser

3.6: WaterLase

WaterLase dentistry is one of the most advanced dental treatments today. WaterLase uses a patented technology that combines focused light energy with a stream of water for a highly precise, exceptionally gentle dental experience. A pain-free procedure without needles or drills. combination of a water-energizing laser and air and water hand piece that combine to symbiotically excite water molecules from within both the spray and the target tissue. This results in a biological, effective micro-ablation of tooth structure, bone, or soft tissue[42].

Figure17: WaterLase device.

3.6.1: Benefits of waterLase

Faster healing time and less trauma to teeth and gums. Less anesthetic for most procedures. Treating dental needs in more than one part of the mouth in one visit. Reduces risk of cross contamination making dental care a more relaxing experience [42].

3.6.2: Uses of waterLase in dentistry

1-Improve smile:- Shaping gum and remove excess gum tissue (gummy smile) .

2-Remove oral growth:- Quickly and safely remove growths gum tissue over an unerupted tooth.

3-Fix a ‘tongue tie’ Connections that restrict the movement of the tongue.

4- Prevent gum recession with less post-operative pain.

5-Treat periodontal disease :- Treatment includes professionally cleaning the sockets around teeth, to prevent damage to surrounding bone, along with medication and surgical procedure [43].

CHAPTER FOUR

4. Conclusions :

From all the collecting studies that were reviewed in this article ,the following points of conclusion have been obtained :

1- The use of laser in dentistry is proven to be the beneficial in treating a wide range of dental conditions as well as a therapeutic tool in tissue management.

2- Diode laser application is rapid, efficient, and safe. It is well- accepted by young patients because it is painless and has no postoperative complications.

3- The data obtained from the review, display a lack of high quality study, with proper sample size and adequate follow up period. Further, randomized clinical trials are required, for forming a reliable scientific evidence, that can guide the paedodontist in formulating a best treatment option in case of paediatric oral ranula.

4- The use of laser offers a new tool that can change the way in which existing treatments are performed, or serve to compliment them. Modern medicine needs to explore and take advantage of current trends to derive maximum benefit in terms of technology, patient's acceptance and, post-operative management.

5- Keeping in view the excellent results which were achieved in the studies concerning CO2 laser treatment of oral soft tissue benign lesions, numerous advantages of CO2 laser over other surgical techniques and less rates of recurrence and other complications as compared to other surgical methods, CO2 laser should be more routinely used in management of oral soft tissue benign lesions.

6- Clinical relevance LLLT may be an additional effective tool for managing dry sockets in general dental practice.

7- The laser energy also poses risks at the same time.

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