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REVIEW ARTICLE

LASERS IN MAXILLOFACIAL SURGERY: A REVIEW

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Abstract

Lasers are becoming the standard of care for many oral and maxillofacial procedures, and they are being introduced as an efficient instrument for a variety of new applications within the specialty. Lasers are becoming increasingly popular due to the advent of office-based lasers, which are small, portable, and easy to manipulate within the oral cavity. Approximately 10% to 20% of all oral and maxillofacial surgeons use a laser in office-based practice, and most have access to lasers in the hospital. The acceptance of lasers as viable alternatives to traditional methods in surgery was one of the events that created an explosion of interest in the last decade.

Introduction:-

In 1960, Theodore Maiman, developed the first working laser device, which emitted a deep red colored beam from a ruby crystal. During the next few years, researchers studied possible applications of this visible laser energy. Studies in the 1970s and 1980s turned to other devices, such as CO and neodymium YAG (Nd:YAG), which were thought to have better interaction with hard tissues. The medical community in the mid to late 1970s had begun to incorporate lasers for soft-tissue procedures and surgeons added the technology in the early 1980s.[1]

The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Light is a form of electromagnetic energy that travels in waves at constant velocity. The basic unit of light is a photon. A wave of photons can be defined by three basic properties. The first is Amplitude which is defined as the total height of the wave oscillation from the top of the peak to the bottom. It is the measurement of the energy in the wave. The energy can be measured is joules. The second property is the Wavelength. It is defined as the distance between any two corresponding points on the wave. It is the measurement of physical size measured in meters. The third property is Frequency which is a measure of the number of oscillations per second. The basic unit of this energy is called a photon. Laser light possesses three additional characteristics: Collimation, Coherency, and Efficiency.[2]

There are five interaction mechanisms associated with the use of lasers in biomedicine[3]:-

Optical effect i.e. fluorescence spectroscopy for cancer screening, optical coherence tomography (OCT) for high-resolution imaging Photomechanical effect (photoacoustic) i.e. for laser lithotripsy, removal of tattoos and certain pigmented lesions Photochemical effect i.e. photodynamic therapy (PDT), chemical reaction stimulation Photothermal effect i.e. laser resurfacing, treatment of vascular lesions, laser hair removal and Photobiostimulative and Photobiomodulative effect i.e. low level laser therapy (LLLT), laser acupuncture, collagen remodeling for aged skin, antiinflammatory treatments, blue light therapy for acne treatments, accelerated wound healing.

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Review Of Literature:-

Lanzaframe RJ (1986)[4] determined the effect of CO2 laser surgery on the incidence of local recurrence following tumor recurrence and to study the effect of "sterilization" of the operative site on this phenomenon. Sixty Fisher 344 rats were implanted with R323OAC mammary carcinoma. Animals were anesthetized with intraperitoneal pentobarbital, and all tumours were completely excised at 21 days postimplantation. The animals were randomized into groups of 12. Animals were observed for recurrence for 33 days postoperatively. Mortalities were excluded from analysis. The author concluded that the CO2 laser is an effective surgical adjunct to reduce local tumor seeding and recurrence. This effect was enhanced by "sterilizing" the surgical site with the defocused laser beam.

White JM (1991)[5] stated the application of a neodymium: yttrium-aluminum-garnet (Nd:YAG) laser compared to conventional scalpel in dental soft tissue surgery. Two surgery sites on 29 patients were randomly selected and treated. An additional 41 patients were exclusively treated with the Nd:YAG laser. Surgical prognosis was made at the time of surgery and compared to actual healing 1 week and 1 month after surgery. No differences were observed between laser and scalpel surgery in terms of pocket depth reduction, postoperative pain, post-operative inflammation, and treatment time. However, operative and postoperative bleeding with laser surgery was significantly less than with conventional surgery. Anaesthesia is required for scalpel surgery, the majority of laser-treated sites evoked minimal pain without anaesthesia. These results indicated that the Nd:YAG laser can be used successfully for intraoral soft tissue applications are well tolerated without anaesthesia and minimal bleeding compared to scalpel surgery.

Hendler BH (1992)[6] reviewed on holmium:YAG (yttrium-aluminum-garnet) laser physics, its tissue effects, and reports initial experience with its use in TMJ arthroscopy. Because the Ho:YAG laser can precisely and rapidly resect cartilaginous tissues with only moderate necrosis, can function in a saline environment, and can be transmitted through conventional optical fibers, author concluded the potential of becoming a useful and adaptable system for TMJ arthroscopic surgery.

Walsh, L. J. (1992)[7] provided an overview of the use of lasers in laboratory and clinical techniques used in implantology, with particular reference to carbon dioxide, Nd:YAG, argon, and erbium:YAG lasers. From a consideration of how particular laser wavelengths interact with metallic and ceramic implant materials, and with bone and soft tissues, principles for the rational and safe use of lasers were deduced.

Schoelch M (1999)[8] assessed the efficacy of laser therapy for the management of premalignant oral lesions. The study group consisted of seventy consecutive laser-treated patients with oral leukoplakia. The microscopic diagnosis included idiopathic focal keratosis, dysplasia of all grades, and verrucous hyperplasia (proliferative verrucous leukoplakia). Thirty-nine patients had some degree of microscopic dysplasia and six demonstrated high-risk proliferative verrucous leukoplakia. The author concluded that Laser surgery of oral leukoplakia is an effective tool incomplete management strategy that includes careful clinical follow-up, patient education to eliminate risk factors and report suspicious lesions, and biopsy of suspicious lesions when appropriate. However, recurrence and progression to cancer remain a risk.

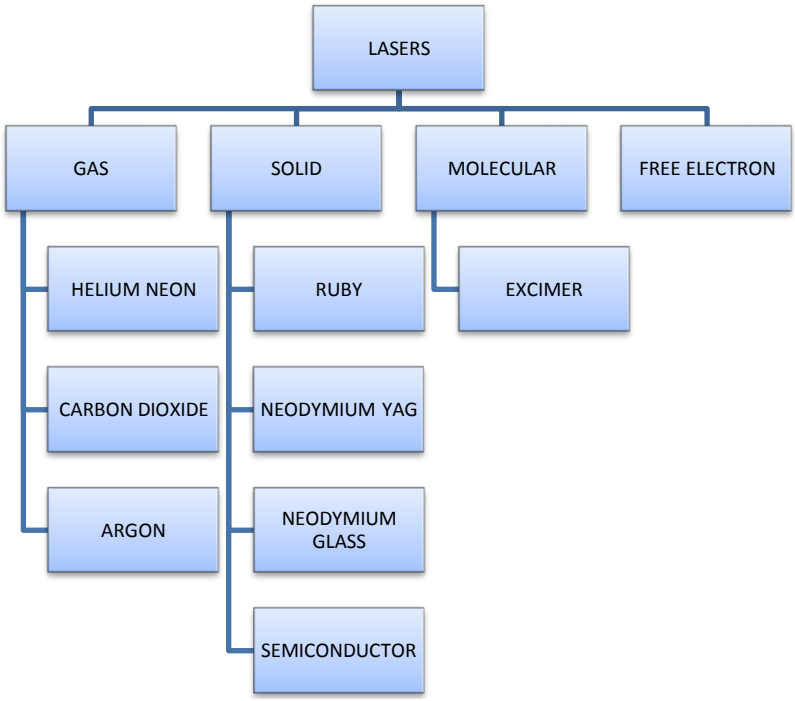
Thompson P (2002)[9] reviewed the records of 57 consecutive laser-treated patients presenting over a 4-year period, with histologically confirmed dysplastic lesions. Leukoplakias were the commonest clinical lesions (69%), whilst the floor of the mouth was the most frequent anatomical site (42%). Laser surgery successfully excised 55 precancerous lesions, 11 of which exhibited more severe dysplasia or neoplasia compared with initial biopsy. Postoperative scarring and morbidity were minimal. After surgery, patients were followed for between 1 and 44 months (mean 18 months). Of these patients, 76% remained disease-free, whilst 24% developed new dysplastic lesions at distinct or multiple sites, often exhibiting increased dysplasia. Of the patients experiencing recurrence, 7% developed OSCC, whilst a further 3.5% presented with other aerodigestive tract cancers. Neither initial lesion appearance nor histological diagnosis predicted clinical behaviour. Interventional laser surgery is thus advised, in contradistinction to conservative management of oral precancers, to facilitate efficacious, low-morbidity treatment and to establish definitive histological diagnosis. As a consequence of field change carcinogenesis, regular follow up of treated precancer patients is mandatory for effective tertiary prevention.

Chaudhry Z (2014)[10] treated a case series of 16 cases of moderate OSMF treated with Erbium Chromium Yttrium Scandium Gallium Garnet (ErCr:YSGG) by laser fibrotomy under local anaesthesia in combination with cessation of habits, topical steroids, lycopene and oral physiotherapy were presented. The mean increase in mouth opening

achieved at 1 year was 17.5 mm. The mean difference in the preoperative and 1 year mouth opening was found to be statistically significant. The mean difference in the preoperative and six-month Visual Analogue Scale scores for oral burning sensation and Oral Health Impact Profile-14 scores for assessment of oral health-related quality of life was statistically significant implying improvement and concluded that ErCr:YSGG laser fibrotomy under local anaesthesia is a minimally invasive, cost effective, chair-side procedure and an useful adjunct in management of moderate OSMF.

Pakfetrat A (2014)[11] investigated the efficacy of CO2 laser surgery for management of refractory erosive-atrophic OLP. Ten patients with thirteen erosive-atrophic OLP resistant to standard therapy were taken. The size and clinical scores of the lesions and the level of pain/discomfort were recorded before treatment. The lesions were then removed with a CO2 laser device (10600 nm, continuous wave, 5 W, slightly defocused). The subjects were evaluated 1 month and 3 months later and the response rate was assessed according to the decrease in pain, sign scores and size of the lesions. There was a significant reduction in pain and lesion size at 1 and 3 months following laser treatment ($p<0.05$). The sign scores of the lesions were also significantly improved at follow-up periods compared to the pretreatment state ($p<0.05$). At the end of the follow-up period, 54% of the lesions showed 3 or 4 degrees of improvement in the clinical score and 23% improved 1 or 2 degrees, whereas 23% remained unchanged post-operatively compared to the pretreatment evaluation. The present results indicated that the CO2 laser surgery is an effective modality for management of erosive-atrophic OLP and can be considered as a suitable alternative to standard treatment.

Classification Of Lasers[12]



Esthetic And Plastic Indications[12]

Lasers have been used for more than 25 years in cosmetic surgery of the face. Superficial vascular and pigmented lesions are most commonly treated with use of argon laser. Nd:YAG laser is used for treatment of deep vascular lesions and tumours. CO2 laser is indicated for vaporization of exophytic lesions. One of the more common procedures performed with laser is cosmetic skin resurfacing by removing the surface layer of the epidermis and superficial papillary dermis, contracting the dermal collagen, and allowing the skin to reepithelialize in a more uniform manner. The advantage of the laser surgery in cases of aesthetic and plastic surgery is based on hemostasis, decreased scarring and decreased postoperative disability

Surgical Indications In Children[12]

In cranio-maxillofacial surgery, laser therapy is indicated in the treatment of congenital vascular malformations, such as hemangiomas or naevi flammei which are treated by argon, Nd:YAG or dye lasers. Moreover, use of the CO2 laser was shown to be effective in cleft surgery of infants

Temporomandibular Joint Laser-Assisted Surgery[12]

Arthroscopic surgery has become the treatment of choice for internal derangements of the temporomandibular joint using Er:YAG, CO2 and Ho:YAG lasers. Using this technique, procedures such as discectomy, discoplasty, synovectomy, hemostasis, posterior attachment contraction, and eminectomy can be performed on an outpatient basis through two incisions less than 2mm each.

Laser Osteotomy[13]

Experimental laser osteotomies were performed in vitro and in vivo with use of different wavelengths including excimer lasers, Er:YAG, CO2 and Ho:YAG lasers. The laser light surgery in cases of squamous cell carcinoma using a new photosensitizer meta-tetrahydroxyphenylchlorine (m-THPC). Intraoperative fluorescence-guided resection followed by PDT seem to be highly promising in improving the radicality of tumor resection combined with a conventional therapeutic approach

Dental Implantology

The most important indication of laser treatment in implantology is application in the peri-implant soft tissues, as well as decontamination of the implant surfaces in order to treat peri-implant bony defects and rehabilitate failing implants[12]

The clinical use of lasers in modern oral implantology may be indicated in the different phases of the treatment. Lasers may be useful in pre-implant treatments when mucogingival surgery is required[14]

Laser Hemostasis

In modern societies, there is an increasing number of older patients, especially who take anticoagulant drugs. Over the past years, lasers haemostatic properties have been established. Due to deeper penetration in soft tissues, Nd:YAG and diode laser have been very effective. To reduce the thermal effect, pulsed lasers are used. Optical characteristics of blood result in scattering and dispersion of laser light, thereby reducing the adverse effects on bony tissue[13]

There are basically three photothermal techniques for laser use within the oral cavity and on the face: incisional and excisional procedures, ablation and vaporization procedures, and hemostasis. Incisional and excisional procedures are common in cases of soft tissue laser surgery using the laser device essentially as a light scalpel to make relatively deep, thin cuts such as one would do with a scalpel blade. This technique allows the surgeon to perform almost any intraoral procedure that would normally be done with conventional technique, such as incisional and excisional biopsy, lesion removal, or incision for flap access. The main advantages are bloodless surgical field and the reduced need for suturing. Tissue ablation or vaporization is used for removal of the superficial part of the tissue but generally over a fairly large area, as well as for the bone removal. The most common examples are leukoplakias, dysplasias, papillary hyperplasia, and osteotomies. In contrast to incisional procedures in which spot size is kept small by locating the laser at its focal length; vaporization is accomplished by using larger spot sizes. This technique allows removal of a surface lesion in layers of a few hundred microns to 1-2mm at a time. Visualization of tissue anatomy is excellent, owing to the hemostasis, and the layers are identified easily. By removing only the epithelium less damage is done to the underlying tissues, and the risk of inadvertent damage to an underlying nerve, duct, or blood vessel is minimal. Any superficial tissue removal without the need for histologic examination can be treated using this technique. Finally, even in cases in which other modalities of treatment have been used, the laser can be used as a hemostatic tool to stop bleeding in the field and to allow for similar postoperative wound management. The cause of this effect is not coagulation of blood, but rather the contraction of the vascular wall collagen[12]

Advantages Of Lasers[15]

The hemostatic nature of the laser is of great value in Oral & Maxillofacial Surgery allowing the surgery to be performed more precisely and accurately because of increased visibility of the surgical site

Decreased postoperative swelling is characteristic of laser use. Decreased swelling allows for increased safety when performing surgery within the airway and increases the range of surgery that oral and maxillofacial surgeons can perform safely without fear of airway compromise.

Tissue healing and scarring also are improved with the use of the laser. This improvement is due to a combination of decreased lateral tissue damage, less traumatic surgery, more precise control of the depth of tissue damage and fewer myofibroblasts in laser wounds compared with scalpel wounds. Hence, intraoral laser wounds can often be left unsutured unless cosmesis is considered.

Decreased postoperative pain often can be obtained with the use of lasers for surgery. The physiology of this effect is still unknown but probably relates to decreased tissue trauma and an alteration of neural transmission. This advantage becomes most evident in the management of extremely large lesions, in which conventional surgery requiring parenteral drugs for pain control; laser surgery requires nothing stronger than class III narcotics.

Uses Of Lasers[16]

There are basically three photothermal techniques for laser use on soft tissues within the oral cavity and on the face:
Incisional procedures,
Vaporization procedures and
Hemostasis.

When these three techniques are understood, the surgeon only has to decide which one would treat the lesion in question most appropriately and how to control the laser parameters of power, time, and spot size to affect the target best with the least collateral damage.

The use of carbon dioxide laser has been a standard for oral surgical procedures. **(Image 1)**

Image 1: CO2 Laser

The Uses of Lasers in the field of Oral & Maxillofacial Surgery are:
Frenectomy
Incisional and excisional biopsies.
Removal of benign lesions
Gingivoplasty
Soft tissue tuberosity reduction.
Soft tissue distal wedge procedure.
Gingivectomy
Removal of hyperplasias
Removal of hyperkeratotic lesions
Removal of pre-malignant lesions

Removal of malignant lesions (multidisciplinary approach)
Removal of vascular lesions
Pyogenic granuloma
Removal of lesion in patients with hemorrhagic disorders.
Implants – Stage II – at the time of recovery.
Soft tissue removal

Understanding the physics involved, it is easy to see that this technique would require a fairly high-power density using a small spot size to create a deep but thin cut, as would be needed to make an incision. It is generally ideal to keep the spot size to whatever is the smallest practical spot size possible with the particular laser (usually 0.1–0.5 mm) because this result in the thinnest cut, closely replicating the cut made with a standard scalpel blade. This approach is called "focused mode" because the smallest possible spot size occurs at the focal length of any particular laser, which varies from 1 mm to about 1 cm from the end of the handpiece.

The basic technique for incision and excision remains the same no matter the particular system used. It is always a good idea to begin the procedure by outlining the intended incision line. This outlining can be done on most machines by using an intermittent, pulsed, or gated mode with a rate of 10 to 20 pulses per second and a low enough fluence per pulse to allow for a superficial mark on the surface of the target without deep penetration. This approach allows the surgeon to delineate the needed margins, if any, in a slow, controlled motion and allows the procedure to be repeated and adjusted. When this procedure is completed, the laser can be changed to a continuous mode, and the dots are connected to create the desired incision. This connection should be done in a rapid yet controllable, continuous fashion to create a single-depth cut with minimal adjacent thermal damage. If a single pass is inadequate to obtain the desired depth, a second pass can be performed and repeated as necessary until the appropriate depth is reached, usually the submucosa for most oral lesions.

Conclusion:-

Laser technology is widely used in oral & maxillofacial surgery in diagnostics and treatment. Before initiating treatment, the number and location of facial scars must be considered. Spot resurfacing is indicated when few atrophic scars exist. A common use of lasers in OMS is to use the device essentially as a light scalpel, using the laser to make relatively deep, thin cuts much as one would do with a scalpel blade. This technique allows the surgeon to perform almost any intraoral procedure that normally would be done with a scalpel, such as incisional or excisional biopsy, lesion removal, or incision for flap access. During the immediate postoperative course, the patient should expect intense erythema, edema, and serous discharge. Therefore, it is incumbent on the surgeon to understand the physics of laser surgery to ensure that these risks are minimized.

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