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Lasers Implications in Prosthodontics: A Review

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Abstract: ***The advent of lasers was one of the most significant developments in the evolution of contemporary prosthodontics. Several technologies have been developed, such as computer - aided design and rapid prototyping technologies, as well as occlusion research in complete dentures using a three - dimensional laser scanner. Its applications span from fixed prosthodontics to dentinal hypersensitivity therapy to base metal alloy surface treatment. Dental implantology and maxillofacial prosthodontics are also included. This article reviews and investigates many studies on the use of lasers in prosthodontics.***

Keywords: Lasers, Implications, Prosthodontics, Advances, Current Trends, Implantology

1. Introduction

Laser is an acronym which stands for “Light Amplification by Stimulated Emission of Radiation”, which have been used in many fields. In the past century, many ideas and discoveries have led to the invention of the laser, each building upon the ones that came before it. The optical MASER (Microwave Amplification by Stimulated Emission of Radiation), which was created by Charles Townes in September 1957 and is the forerunner of laser technology, is an example of such a concept. Gordon Gould, a Columbia University graduate, was the first to invent the terminology laser in 1957. The first successful device (ruby laser) was created by Theodore H. Maiman of California on July 7, 1960, after several efforts by many scientists.[1, 2]

2. Laser Physics

A laser is made up of a beam of light with multiple wavelengths that has a low convergence. They are in the near infrared (NIR) spectral range of light.

The basic components of laser are:

1) **Optical resonator**: The portion of the laser that consists of two mirrors on either side of the laser bulb, one highly reflective and the other somewhat reflecting.
2) **Laser gain / active laser medium**: The source of optical gain in a laser that occurs from stimulated emission is known as the active laser medium. A pump source is used to stimulate the medium. Semiconductors such as gallium arsenide and gallium nitrate, as well as gases such as helium and neon mixes, are examples.
3) **Pump source**: Pumping is the act of transferring energy from an external source into a laser's gain medium. Optical pumping, electrical pumping, gas dynamic pumping, and other pumping methods are examples of such methods.

External energy excites the grain medium, which is pumped up and generates photons that go back and forth between the resonators, producing energy, and the exit channel is supplied in one of the resonators, resulting in Laser generation.

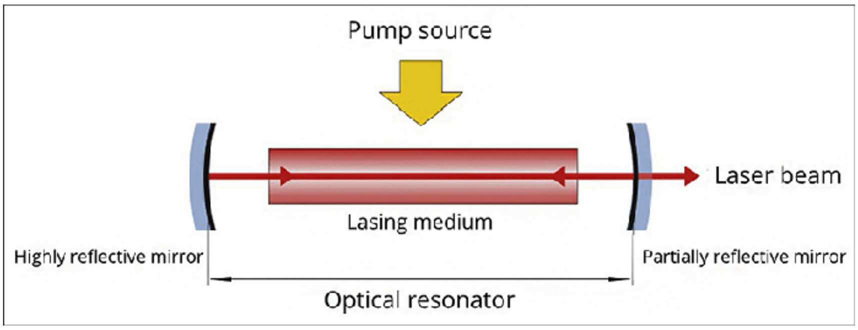

Figure 1: Basic components of laser (Black &Jobling, 2014, modified)

The basic principles involved in laser action are,

a) **Quantum nature of light:**
Quantized energy levels are limited for atoms and molecules. Absorption, emission, and stimulated emission are the processes that transition between these quantized states.
b) **Stimulated emission:**
If an electron is already excited, an incoming photon with quantum energy equal to the energy difference between its current level and a lower level might "stimulate" a transition to the lower level, resulting in the emission of a second photon with the same energy.

3. Lasers in dentistry

Erbium, Nd: YAG (Neodymium Yttrium Aluminium Garnet) diode, and CO_2 are the most commonly utilised dental lasers nowadays. There are biological consequences and processes inherent with each type of laser.1[0]
There are three types of lasers that are used in dentistry they are:

a) Soft tissue lasers.
b) Hard tissue lasers.
c) Non surgical lasers.

Classification of lasers according to the Lasing medium[4]

Laser Type	Dental Application
Excimer lasers	
Argon Fluoride (ArF)	Hard tissue abrasion
Xenon Chloride (XeCl)	Dental calculus removal
Gas Lasers	
Argon (Ar)	Tooth whitening, curing of composite materials, sulcular debridement, intraoral soft tissue surgery
Helium Neon (He - Ne)	Analgesia, dentinal hypersensitivity
Carbon Dioxide (CO_2)	Intra oral and implant soft tissue surgery, Analgesia
Diode Lasers	
Indium Gallium Arsenic Phosphorus (InGaArP)	Caries detection
Erbium family of lases	
Er: YAG	Caries removal and cavity preparation
Er: Cr: YSGG	Modification of enamel and dentin surface
	Uncovering of implant, soft tissue surgery
Gallium Aluminium Arsenide	Intra oral and implant soft tissue surgery, sulcular debridement
Solid state lasers	
Frequency doubled alexandrite	Selective ablation of dental caries
Nd: YAG	Intra oral soft tissue surgery, sulcular debridement, analgesia

Lasers are used and applied in prosthodontics for procedures such as:

1) In removable prosthesis, their uses include:
- Treatment of enlarged tuberosity
- Surgical treatment of Tori and exostoses
- Treatment of alveolar ridge undercuts
- Unsuitable alveolar ridge treatment
- Soft-tissue lesions.
- Laser welding

2) Complete denture
- Prototyping & CAD/CAM Technology
- forming of a complete titanium denture base plate
- complete denture study for occlusion using by three - dimensional technique
- Analysis of accuracy of impression by laser scanner

3) Fixed prosthodontics
- Crown lengthening – soft and hard tissue
- Laser troughing
- Modification of soft tissues around laminates and abutments
- Altered passive eruption management
- Formation of ovate pontic sites
- Removal of veneer
- Crown fractures at the gingival margins:

4) In implantology, their application in various procedures includes:
- For decontamination of socket
- Implant recovery
- Second stage uncovering
- In case of peri - implantitis
- Removal of diseased tissue around the implant
- Sinus lift procedure
- Role of lasers in mini implant placement

5) Maxillofacial rehabilitation
- Sintering with CAD/CAM technology

6) Laser applications in the dental laboratory

Complete Denture Prosthetics and Lasers

a) Prototyping & CAD/CAM Technology:

Rapid prototyping (RP) is a phrase that refers to a group of technologies that can automatically create physical models from CAD data. Instead of only two - dimensional drawings, these "three - dimensional printers" allow designers to instantly manufacture real prototypes of their concepts. Rapid prototyping is an additive procedure that creates a solid item by layering paper, wax, or plastic. Because of its additive nature, RP can make objects with complex interior characteristics that are impossible to make any other way.

b) LASER rapid forming of a complete titanium denture base plate: [16]

For producing the titanium plate of a full denture, this process combines the CAD/CAM and LRF (Laser Rapid Forming) technologies. Denture base plate was structured and cut into a sequence of numerical controlled codes using a laser scanner, reverse engineering tools, and standard triangulation language (STL). On the LRF system, the denture plate will be created layer by layer. This denture plate will be appropriate for usage in patients after typical finishing processes.

c) Study of complete denture occlusion using by three - dimensional technique: [17]

With the use of a laser scanner and three - dimensional reconstruction, the occlusion may be evaluated and investigated after the production of new dentures. The link between the balanced occlusion parameters can also be investigated.

d) Analysis of accuracy of impression by laser scanner: [18]

Scanner laser three - dimensional (3D) digitizers can output x, y, and z coordinates without actually touching the surface. The digitizer records data as the number of points on a surface with a resolution of 130 mm at 100 mm. Due to these rigorous characteristics, the laser digitizer may estimate the size of dental impression materials correctly and reliably without subjectivity. Building up an image based on landmarks enables superimposition and calculation of differences between two identical images.

4. Removable Prosthetics

The creations of removable full and partial dentures depend on the preoperative analysis of the supporting hard and soft tissue structures and their proper preparation.3 Lasers are now used for most preprosthetic operations. Using lasers to manipulate the soft tissues and underlying osseous structure of removable prosthetic devices can enhance stability, retention, function, and aesthetics.

a) Unsuitable alveolar ridge treatment:
Alveolar resorption has rather homogeneous vertical and lateral dimensions. To flatten the residual ridge, soft tissue laser surgery may be conducted with any number of soft tissue wavelengths (CO_2, diode, Nd: YAG,) whereas hard tissue surgery can be performed using the erbium family of wavelengths.

b) Treatment of undercut alveolar ridges:
Dilated tooth sockets caused by insufficient compression of the alveolar plates following dental extraction and non - replacement of a broken alveolar plate are two of the most prevalent causes of undercut alveolar ridges. Any of the soft tissue lasers can be used for soft tissue surgery. The **erbium family** of lasers can be used for osseous surgery.

c) Treatment of enlarged tuberosity:
Unopposed maxillary molar teeth cause hyperplastic tuberosity, which may lay on the palate, as well as hyperplastic soft tissues. Hematoma development is a frequent surgical torus reduction complication. Non - hematoma development has been detected during laser torus removal. The use of erbium and CO_2 in combination aids in bone recontouring and hemostasis.6

d) Surgical treatment of Tori and exostoses:
If the maxillary tori or exostoses are big or uneven in form, prosthetic issues may occur. Compact bone makes up the majority of tori and exostoses. Tori are frequently seen in the premolar area. Ulceration and severe pain are common side effects of the design and production of removable dental prostheses covering the tori and exostosis areas. The use of lasers such as Ar, XeCl, and Nd: YAG aids in the removal of both hard and soft tissues.[7]

e) Soft-tissue lesions:
A fibrous tissue reaction can occur as a result of repeated stress from a sharp denture flange or over compression in the posterior dam region. Soft tissue lasers such as Nd: YAG, CO_2, and diode lasers can be used to remove hyperplastic soft tissue growth and improve reepithelization.

f) Laser welding[21]
The pulsed laser with low average out power is one of the current ways of repairing removable partial denture defects. This approach is recognised for being exact and fast, but its effectiveness is contingent on the management of a number of variables.

For example, welding settings for Co - Cr alloy frameworks were calculated for each defect type and working phase (fixing, joining, filling and planning).

Depending on the working stage, an appropriate combination of pulse energy (6 - 14 J), pulse length (10 - 20 ms), and peak power (600 - 900 W) optimises the welding procedure's performance.

5. Fixed Prosthodontics

a) Crown lengthening:

Appropriate crown length is crucial for better aesthetics and functional value, and is usually advised for teeth with:

- Caries at marginal gingiva level[5]
- Cuspal fracture that extends below the level of gingival margin
- Insufficient clinical crown length
- To enhance esthetic value (i. e.,) in cosmetic use
- When placement of finish line is difficult.

Any of the soft tissue lasers can be used for soft tissue operations. The **erbium family** of lasers is used for osseous recontouring. After surgery, provisionalize the region and wait 3–4 weeks for it to recover before making a final imprint.

b) Laser troughing:
It's possible to form a trench around a tooth with lasers before taking an impression. Retraction cords, electrocautery, and the use of haemostatic drugs can all be eliminated with this method. The outcomes are predictable, efficient, and save chair time by minimising epithelial attachment impingement, causing less bleeding during the succeeding impression, and reducing postoperative issues.8 It alters the gingiva's biological width**. Nd: YAG** lasers are used.

c) Modification of soft tissue around laminates and abutments
With the argon laser, gingival tissue cover removal and re - contouring may be done quickly and effectively. The laser can be employed as a main surgical instrument to remove diseased or non - diseased gingival tissue as a result of medication therapy or orthodontic treatment. The laser will remove tissue, provide hemostasis, and allow tissues to reattach to the wound. Gingivoplasty may also be done using **argon laser.**

d) Altered passive eruption management:
Lasers can be used to treat altered passive eruption of teeth with uneven margins by removing and recontouring soft tissues such as gingiva margins with minimum complications, hence improving aesthetics.

e) Formation of ovate pontic sites: [19]
An unattractive and non - self - cleaning pontic design is the outcome of an inappropriate pontic location. Soft and bony tissue recontouring may be required for a good pontic

design. Any of the soft tissue lasers may be used for soft tissue surgery, and the **erbium family** of lasers can be used for osseus surgery.

f) Removal of veneer:

Laser energy passes through porcelain glass which is unaffected and is absorbed by water molecule at the adhesive. Debonding occurs between silane and resin without damaging the underlying tooth.9 Lasers such as Er, Cr: YSGG are used for removal of unwanted or failed veneers[10]

g) Crown fractures at the gingival margins:

Er: YAG or Er, Cr: YSGG lasers can be moved out to permit correct exposure of the fracture margin.1[1]

6. Implantology

a) For decontamination of socket[20]

If there is no infection following tooth extraction, the socket can be sterilized quickly and painlessly in rapid implant dentistry. When teeth are pulled and implants are placed directly into the extraction site, decontamination is also necessary. **Erbium lasers** eliminate soft tissue remains and decontaminate bone surfaces at lower powers and with the use of a water - coolant spray**. CO_2 lasers** are also an excellent choice because they can remove soft tissue tags with a low power and clean bones.

b) Implant site recovery:

The implant can be exposed and imprints obtained at the same time by employing lasers. A number of lasers can be used to remove dental implants. As a result of the limited tissue shrinking caused by laser surgery, the tissue borders will be level after healing. Furthermore, the laser approach may separate the damage induced by flap reflection and suture insertion from the tissues.

c) Second stage uncovering

This can be accomplished with any laser wavelength except Nd: YAG laser, because of its adverse effects on dental implants. If the soft tissue is not too thick (1 - 2 mm), all wavelengths except Nd: YAG can be used. The CO_2 laser is most efficient to remove thick soft tissue quickly and maintain unobstructed vision of the surgical site.

d) Mucositis and peri implantitis

For patients with mucositis and periimplantitis, lasers offer a newer and more effective treatment option. This can be done with an erbium laser, a CO_2 laser, or a diode laser. The CO_2 laser may be reflected off the implant's surface and melt microorganisms in deep bone lesions, resulting in a more comprehensive implant site cleansing.

e) Removal of diseased tissue around the implant:

Lasers can be used to restore implants by sterilizing their surfaces with laser energy. Diode, CO_2& Er: YAG lasers can be used for this reason. Lasers can be used to remove granulation tissue in case there is inflammation around an Osseointegrated implant.[12, 13]

f) Sinus lift procedure

The sinus lift operation can potentially make use of lasers. The treatment can be performed with a lower risk of sinus membrane puncture by performing a lateral osteotomy. When it comes to not cutting the sinus membrane, the yttriumscandium - galium - garnet (YSGG) laser is the best option. The osteotomy for a ramal or symphyseal block graft can also be made using the YSGG laser. Bone grafts done with lasers have been demonstrated to decrease the amount of bone necrosis from the donor site and the osteotomy cuts are narrower, resulting in less postoperative pain and edema.

g) Role of lasers in mini implant placement

A tiny hole might be made into the soft tissue and roughly 3 mm into the bone following the approach described by Balkini et al. These 1.8mm diameter micro implants with a self - tapping thread may be rotated gently and autoadvanced into soft cancellous bone. There may be an advantage to laser sterilizing the bone as it penetrates and produces an osteotomy site.2[2]

7. Maxillofacial Rehabilitation

The Laser Holography Imaging procedure can be used to collect data about the patient's deformity using laser surface digitizing tools.

Sintering with CAD/CAM technology:

In comparison to more traditional approaches for creating face prosthesis, new breakthroughs in fast prototyping technology have showed substantial advantages. The use of selective laser sintering technology for producing a wax template of a maxillofacial prosthesis is an alternate method. This new approach can generate the wax pattern directly and reduce labour - intensive laboratory procedures.1[4]

Laser applications in the dental laboratory

Comparing conventional acid etching with surface treatment of titanium castings to improve bond strength with porcelain, the bond strength has been improved. In addition to welding, lasers can also be used for the development of prototypes, the development of CAD/CAM technologies, the analysis of occlusion by CAD/CAM, the measurement of impression accuracy by laser scan, and laser titanium sintering to sinter titanium components of prosthetic devices.1[5]

8. Conclusion

The introduction of lasers into dentistry and prosthodontics has helped to increase the success rate of prostheses and has helped patients regain form, function, and aesthetics. By controlling both the power output and the duration of exposure, laser dentistry advances dental treatment methods in the dentist's ability to treat a highly specific area without damaging nearby tissue. As patients become more aware of laser treatments, the relationship between the dentist and the patient is intensified.

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