LASERS IN DENTISTRY

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❖ CLASSIFICATION AND NOMENCLATURE OF LASER

❖ ADVANTAGES OF LASER OVER CONVENTIONAL TREATMENTS
  ✓ Soft tissue
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  ✓ Endodontics
  ✓ Periodontics

❖ LIMITATIONS OF LASER
BASICS OF LASERS AND LASER LIGHT

<table>
<thead>
<tr>
<th>L</th>
<th>Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Amplification by</td>
</tr>
<tr>
<td>S</td>
<td>Stimulated</td>
</tr>
<tr>
<td>E</td>
<td>Emission of</td>
</tr>
<tr>
<td>R</td>
<td>Radiation</td>
</tr>
</tbody>
</table>
CHARACTERISTICS OF LASER LIGHT

MONOCHROMATIC

DIRECTIONAL

COHERENT

The combination of these three properties makes laser light focus 100 times better than ordinary light.
The Active Medium contains atoms which can emit light by stimulated emission.

The Excitation Mechanism is a source of energy to excite the atoms to the proper energy state.

The Optical Resonator reflects the laser beam through the active medium for amplification.
CLASSIFICATION & NOMENCLATURE
Dental laser

- Hard laser
  - Cold laser
    - ArF, XeCl
  - Hard tissue laser
  - Soft tissue laser
  - Composite curing laser

- Soft laser
  - Biostimulation PDT
  - Caries detection Aiming beam
Classification based on active medium

- Dye Lasers,
- Gas Lasers,
- Chemical Lasers,
- Metal vapour Lasers,
- Solid state Lasers,
- Semi conductor Lasers

and other types.
# Dye laser

<table>
<thead>
<tr>
<th>Laser gain medium and type</th>
<th>Operation wavelength(s)</th>
<th>Pump source</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dye laser</td>
<td>390-435 nm (stilbene), 460-515 nm (coumarin 102), 570-640 nm (rhodamine 6G), many others</td>
<td>Other laser, flash lamp</td>
<td>Research, spectroscopy, birthmark removal, isotope separation. The tuning range of the laser depends on which dye is used.</td>
</tr>
</tbody>
</table>
## Chemical laser

<table>
<thead>
<tr>
<th>Laser gain medium and type</th>
<th>Operation wavelength(s)</th>
<th>Pump source</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen fluoride laser</td>
<td>2.7 to 2.9 μm for Hydrogen fluoride (&lt;80% Atmospheric transmittance)</td>
<td>Chemical reaction in a burning jet of ethylene and nitrogen trifluoride (NF3)</td>
<td>Used in research for laser weaponry by the U.S. DOD, operated in continuous wave mode, can have power in the megawatt range.</td>
</tr>
</tbody>
</table>
## Metal vapour laser

<table>
<thead>
<tr>
<th>Laser gain medium and type</th>
<th>Operation wavelength(s)</th>
<th>Pump source</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium-cadmium (HeCd) metal-vapor laser</td>
<td>441.563 nm, 325 nm</td>
<td>Electrical discharge in metal vapour mixed with helium buffer gas.</td>
<td>Printing and typesetting applications, fluorescence excitation examination (i.e. in U.S. paper currency printing), scientific research.</td>
</tr>
</tbody>
</table>
## Laser Gain Medium and Type

<table>
<thead>
<tr>
<th>Laser Gain Medium and Type</th>
<th>Operation Wavelength(s)</th>
<th>Pump Source</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium sapphire (Ti:sapphire) laser</td>
<td>650-1100 nm</td>
<td></td>
<td>Spectroscopy, LIDAR, research. In amplifier lasers to produce ultrashort and ultra-intense pulses.</td>
</tr>
</tbody>
</table>
ADVANTAGES OF LASER

IN SOFT TISSUE
SURGERY

IN HARD TISSUE
ADVANTAGES OF LASER DURING SOFT TISSUE SURGERY

- Laser use offers improved hemostasis compared to scalpel.
- Laser energy can reduce pain (needle less anesthesia).
- Laser use is minimally invasive.
- Laser irradiation can reduce bacteria.
- Laser energy can aid healing through photobiomodulation.
- Reduced patient anxiety, thus increased patient cooperation.

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1. LASER USE OFFERS IMPROVED HEMOSTASIS COMPARED TO SCALPEL

incision

Denaturation of protein
Blood clot

Laser welding
Showing coagulation and denaturation of protein and collagen
IMPORTANCE OF HEMOSTASIS

- Improved visibility.
- Decreased chair side time.
Clinical significance of controlled hemostasis

- Patient taking anticoagulant, thinners like aspirin, can be treated with lesser risk of profuse bleeding.

- Treatment of vascular lesion.

- One of the most common area that haemostasis is needed by most dental clinicians is during final impression of prepared crown.
2. LASER ENERGY CAN REDUCE PAIN

- 1. Gates theory
afferent nociceptive stimulation of pulpal nerve fibers undergo synapse transmission in the subnucleus chordalis, before onward transmission to the higher brain. Influence of such transmission may be affected by restimulation at a faster speed than the re-formation rate of acetylcholine at the synapse or the polarity reversal rate of the nerve fiber. The synaptic neurotransmitter refractory period is approximately 1 msec, whereas a typical pulsewidth of a free-running laser is 100 to 150 μsec.
● They decrease cell membrane permeability for Na+ and K+ and cause neuronal hyperpolarisation, resulting in increased pain threshold.
● Injured tissue metabolism is increased by electromagnetic energy of laser. This is induced by ATP production and cell membrane repolarisation.
● Low-power lasers increase descending analgesic impulses at dorsal spinal horn and inhibit pain feeling at cortex level.
● They balance the activity of adrenalin and noradrenalin system (autonomous system) as a response to pain.
● Low-power lasers increase the urinary excretion of serotonin and glucocorticoids, increasing the production of β-endorphin.

REF--(Journal of Dental Research, Dental Clinics, Dental Prospects)
also releases PG

Vasoactive amines
1. 5-hydroxytryptamine
2. Histamine
3. Bradykinin

basophils
platelets
Mast cell

PAIN
HYPERMIA
SWELLING

NOCICEPTORS

PAIN

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CLINICAL ADVANTAGE

No pain

No anxiety

No discomfort

15 MINUTE ANESTHESIA

REF--(Journal of Dental Research, Dental Clinics, Dental Prospects)
LASER ENERGY CAN AID HEALING

- Lack of postoperative inflammation and uneventful healing.
- Often if not always, need of dressing or suture can be avoided.
- Lack of postincisional bacterial decontamination due to –
  1. sterile cut
  2. protective layer of coagulum of plasma and other blood products
- Lack of fibroblast alignment associated with incision line and consequently reduced chance of tissue shrinkage through scarring.

Ref—(Steven parker International journal of laser sep-decem.)
Surgery

Tissue injury

Inflammatory response

pain

bacteria

kinins

Immune cells

Cellular activity

Ref—(Steven parker International journal of laser sep-decem.)
Clinical advantage

- Less post operative discomfort.
- Not quicker but Uneventful healing.
- Less postoperative pain and edema
- Better patient compliance

Ref--(Steven parker international journal of laser sep-decem.)
Laser wavelengths have been shown to be absorbed by different components such as haemoglobin, melanin, water, and hydroxyapatite.

Interaction is primarily determined by the laser irradiation affinity for specific chromophores comprising the tissue.

A chromophore is a molecule or substance capable of absorbing specific laser wavelengths.

Ref--(Steven parker International journal of laser sep-decem.)
How to be minimally invasive

- Appropriate wavelength
- Appropriate laser parameter
-- inflamed tissue, which can contain dark pigment and hemoglobin chromophores, readily absorb wavelengths in the visible and near-infrared regions.
**LASER IRRADIATION CAN REDUCE BACTERIA**

<table>
<thead>
<tr>
<th></th>
<th>drugs</th>
<th>Laser sepsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side effects</td>
<td>Systemic</td>
<td>none</td>
</tr>
<tr>
<td>resistance</td>
<td>Yes</td>
<td>no</td>
</tr>
<tr>
<td>Spectrum of activity</td>
<td>Broad/narrow</td>
<td>Pigmented pathogens</td>
</tr>
<tr>
<td>Local delivery mode</td>
<td>Chemical dissolution</td>
<td>Light diffusion</td>
</tr>
</tbody>
</table>
Laser

bacterial

Altered cell permeability

Swelling Due to altered osmotic gradient

cellular death
Drawbacks

- Healing may be prolonged
- Plume generation
- Tissue charring
ADVANTAGES IN HARD TISSUE

- Cavity preparation
- Laser analgesia
- Selective caries removal
- Selective smear layer removal
- In bone removal (osteotomy)
CAVITY PREPARATION

OLD CONCEPT
“extension for prevention,”

MORDERN CONCEPT
“Minimally invasive DENTISTRY”
## Benefits of Laser Use over Rotary Instrumentation (“Airotor”) in Tooth Cavity Preparation

<table>
<thead>
<tr>
<th>Restorative Procedure</th>
<th>rotary</th>
<th>Laser*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting enamel/dentin</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Selective removal of caries</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Precision</td>
<td>Precise &gt;1000-2000μ</td>
<td>Precise &lt;300 μ</td>
</tr>
<tr>
<td>Smear layer</td>
<td>Smear layer produced</td>
<td>No smear layer</td>
</tr>
<tr>
<td>Thermal rise</td>
<td>Thermal rise &gt;15° C</td>
<td>Thermal rise &lt;5° C</td>
</tr>
<tr>
<td>Risk of iatrogenic damage</td>
<td>Greater</td>
<td>Less</td>
</tr>
<tr>
<td>Noise/vibration</td>
<td>&gt;120 dB/vibration</td>
<td>&lt;120 dB/no vibration</td>
</tr>
<tr>
<td>RESTORATIVE PROCEDURE</td>
<td>ROTARY</td>
<td>LASER</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Bactericidal action</td>
<td>No</td>
<td>Surface decontamination</td>
</tr>
<tr>
<td>Speed of cutting enamel</td>
<td>Fast</td>
<td>&lt;30% rotary speed</td>
</tr>
<tr>
<td>Speed of cutting dentin</td>
<td>Fast</td>
<td>Comparable</td>
</tr>
<tr>
<td>Contact with tooth tissue</td>
<td>Contact required</td>
<td>Noncontact possible</td>
</tr>
<tr>
<td>Pain response</td>
<td>High</td>
<td>Less pain/no pain</td>
</tr>
</tbody>
</table>

REF--PRINCIPLE AND PRACTICE OF LASER DENTISTRY, Robert A. Convissar
Scanning electron micrograph of human enamel showing cavity by high speed rotary instrument.
no smear layer, and open dentinal tubules.
The higher the water content of the tissue, the more easily the erbium lasers will cut the tissue.

- Extremely decayed tissue (higher water content) will cut much more easily.
- Healthy enamel (lower water content) will be more difficult to cut.

REF: PRINCIPLE AND PRACTICE OF LASER DENTISTRY, Robert A. Convissar
Methods of selective removal of caries

- Laser
- Carisolv
- Caries dye

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LASER CARIES PREVENTION

- Carbonated hydroxyapatite crystal
- More resistance to acid
- More fluoride uptake

REF--PRINCIPLE AND PRACTICE OF LASER DENTISTRY, Robert A. Convissar
www.ptbd.in / www.proudtoberdentist.com
CLINICAL ADVANTAGES

- Pit and fissure sealant.
- For acid etching for orthodontic brackets.
laser in osteotomy

Laser osteotomy is the treatment of bone tissue using laser systems instead of mechanical tools.

Conventional techniques
1. Cheisel and mallet
2. burs.
Disadvantages of conventional techniques

- >43°C irreversible damage such as membrane damage with edema or denaturation of enzymes
- >60°C necrosis
2. In the case of a drill, a smear layer is produced and saws can generate rough surfaces.

3. Furthermore, the size and shape of traditional mechanical tools often make them unsuitable for geometrically complicated incisions and for minimal invasive treatment.
Advantages

gentle and contact-free preparation technique

no external forces, which is especially useful for porous and brittle bone tissue,

hygienic and sterile,

the nearly complete absence of collateral damage

precise cavity preparation

minimal invasive treatment.

---Ultrashort Pulse Laser Osteotomy V. Wieger*, S. Zoppel, and E. Wintner Photonics Institute, Vienna University of Technology, Gusshausstrasse 27, Vienna, A-1040 Austria

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## Advantages of laser compared to surgical drill

<table>
<thead>
<tr>
<th>Advantages of laser</th>
<th>Compared to surgical drill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent cutting efficiency</td>
<td>2.6 times more bone tissue removed</td>
</tr>
<tr>
<td>Short preparation time</td>
<td>only 17% of drilling time</td>
</tr>
<tr>
<td>Lower temperature</td>
<td>3.8°C lower final temperature</td>
</tr>
<tr>
<td>Regular shapes with clear, sharp</td>
<td>Decreased risk for infection caused by bony particles which remain</td>
</tr>
<tr>
<td>edges</td>
<td>after drill treatment</td>
</tr>
<tr>
<td>No smear layer</td>
<td>Increased adhesion of blood elements at the start of the healing</td>
</tr>
<tr>
<td></td>
<td>process</td>
</tr>
</tbody>
</table>
Selective removal of smear layer

- Smear layer is composed of debris (organic as well as inorganic) compacted into the surface of dentinal wall by the action of instruments.
- This smear layer blocks the accessory canals, lateral canals and dentinal tubules.
- The smear layer consists of a superficial layer on the surface of the root canal wall approximately 1 to 2 μ thick and a deeper layer packed into the dentinal tubules to a depth of up to 40 μ.

Ref: cohen pathway of pulp
Two concepts

- Do not remove the smear layer
- Remove the smear layer

Ref: cohen pathway of pulp
Do not remove the smear layer

- Intact smear layer plug the dentinal tubules microbes and tissue included.
- This plugging may help to prevent bacterial egress from the tubules after treatment and prevent failure.

Ref- cohen pathway of pulp
Remove the smear layer

- Smear layer can slow down the bacterial movement but it does not prevent eventual egress.
- Smear layer should be removed so that sealer and obturation material can reach the lateral and accessory canal and completely seal them.

Ref- cohen pathway of pulp

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Disadvantages of using 5.25% hypochlorite and 17% EDTA

- Decrease in elastic modulus and flexural strength of dentine due to proteolytic action of concentrated hypochlorite on collagen matrix.

Ref: cohen pathway of pulp
### How laser remove smear layer

<table>
<thead>
<tr>
<th>Light activated irrigation</th>
<th>Photon induced photoacoustic streaming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo-thermal and photomechanical phenomena</td>
<td>photoacoustic and photomechanical phenomena</td>
</tr>
<tr>
<td>The expansion and successive implosion of irrigants (by thermal effect) generates a secondary Cavitation effect on the intra-canal fluids.</td>
<td>“shock waves” leading to the formation of a powerful streaming of fluids inside the canal.</td>
</tr>
<tr>
<td>via thermal effect and cavitation, produced movement of fluids in the root canal, leading to an increased ability to remove debris and the smear layer.</td>
<td>No significant thermal effect.</td>
</tr>
<tr>
<td>use of subablative energy of</td>
<td></td>
</tr>
</tbody>
</table>
The canal surface shows a noticeable smear layer and occluded dentinal tubules.

Ref: Effectiveness of the erbium:YAG laser and new design radial and stripped tips in removing the smear layer after root canal instrumentation. E. DiVito & O. A. Peters & G. Olivi.
Considerable erosion of canal-wall dentin occurs when hypochlorite is used after EDTA or C.
Open dentinal tubules with minimal smear layer
Canal wall collagen fibers and internal hydroxyapatite matrices intact and visible after Er:YAG laser irradiation (20 mJ per pulse, 15 Hz, 50 micros pulse duration) for 40 s in 17% EDTA (wet canal)

Ref-Effectiveness of the erbium:YAG laser and new design radial and stripped tips in removing the smear layer after root canal instrumentation
E. DiVito & O. A. Peters & G. Olivi
www.ptbd.in / www.proudtopotedentist.com
Limitation of lasers

- Cost is high
- It does not completely eliminates the use of burs
- Lack of tactile sensation
- No single wavelength can completely performs all the application
- Laser therapy is an adjunct to conventional therapy

Although use of anesthetic is reduced but not completely eliminated
Conclusion

- Although laser has several advantages over conventional treatment procedure but it has not completely replaced it.

- There are few limitations of laser but if correct parameters are used we can avoid these limitations.
Thank You