5) Cutaneous Laser Therapy – Dr. Faraidoon

- Light has long played an important role in the treatment of skin diseases & introduction of lasers continues this important role
- Lasers have an important & respected place in Dermatology practice because Lasers provide remarkably specific, precise, and effective new forms of treatment for many disorders where no therapy previously existed.

**LASER is a device for the**

- creation, } of a narrow,
- amplification &{ intense beam
- transmission } of coherent light

**Historical Aspects**

- 1917 Einstein Quantum Theory
- 1954 Towen MASER (M:Microwave)
- 1957 Gordon Gould (coined the acronym LASER)
- 1960 Maiman Ruby-Laser (1stLaser)
- 1961 Johnson Nd-YAG Laser
- 1962 Bennet Argon Laser
- 1964 Patel CO2 Laser
- 1980 Tunable-Dye
- 1990 FPDL

* Gordon Gould made notes about his ideas for a "laser" in 1957, which became an important ingredient of future lasers. The term "laser" was first introduced to the public

**Physics: Principal components:**

1. Active laser medium
2. Laser pumping energy
3. High reflector
4. Output coupler
5. Laser beam

**Electromagnetic Waves:** Light is a small segment of the electromagnetic spectrum that extends from radio waves to g-rays. Differences between the different waves are the Wavelength (WL) & Frequency

*Electromagnetic spectrum*

- long waves --------> short waves
- Radio waves - Microwaves - Infrared - Visible - UV - X Ray - Y

**LASER** is an acronym for Light Amplification by Stimulated Emission of Radiation

**Differences between**

<table>
<thead>
<tr>
<th>Laser</th>
<th>Conventional light sources</th>
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<tbody>
<tr>
<td>Monochromatic: 1 WL</td>
<td>Many wavelengths</td>
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<tr>
<td>Collimated: 1 direction</td>
<td>Emitted in many directions</td>
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<tr>
<td>Coherent: oscillating (Vibrating) as a stable wave</td>
<td>Incoherent: Not oscillating as a stable wave</td>
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Properties of Laser

1. Monochromic: 1 WL
2. Collimation: 1 direction
3. Coherence: oscillating as a stable wave

Types of Laser: Beams (WLs):

1. Excimer Laser: 308 nm (126-337 nm) in Psoriasis & Vitiligo
2. Argon Laser: 488 and 514 nm
3. KTP Laser:(Potassium Titanyl Phosphat) 532 nm
4. PDL: Pulsed Dye Laser: 577 nm
5. Ruby Laser: 694 nm beam
6. Alexandrite Laser: 755 nm
7. Diode Laser: 808-980 nm
8. Nd:YAG Laser: 1064 nm=(532 X 2)
9. Ho:YAG Laser: 2100 nm
10. Erbium:YAG Laser: 2940 nm
11. Co2 Laser: 10,600 nm

Cutaneous Laser Surgery and Cosmetic Dermatology

- Almost no area of dermatology is changing as rapidly as that of cutaneous laser surgery.
- Development of new laser, as well as improvements in existing laser, continues to advance the field.
- Laser surgery has become an effective therapeutic modality for a variety of dermatologic conditions.
- The first laser, a ruby laser, was operated in 1960 by Theodore Maiman.
- Medical applications were quickly recognized, & Leon Goldman pioneered their dermatologic use
- The WL is determined by the active medium of each particular laser.
- Active medium can consist of:
  1. Gas (i.e. argon or CO2 laser),
  2. Liquid (i.e. dye laser), or
  3. A solid (ruby or yttrium-aluminum-garnet crystal laser)
- Light can interact with incident targets in 1 of 3 ways:
  - 1st Transmitted { In the 1st Transmitted & 2nd
    - Reflected the light
  - 2nd Reflected { has no effect or
  - 3rd Absorbed: the light has effect

Light-Tissue Interactions: Tissue Absorbers

Cutaneous Targets (chromophores) that absorb the laser lights are:

1. Melanin in Hair Epilation
2. Hb in vascular lesions
3. Water in tumors
- Medical procedures: only obtained by absorption of light
- Effects can be controlled by choosing the appropriate WL
- When absorbed, the light energy is transformed into → heat.
- Selective Photothermolysis: In most cases of laser therapy, it is the heat generated by absorption that produces the desired effect. One notable exception is photodynamic therapy
**Selective Photothermolysis:** was originally promoted by Parish and Anderson

Photothermolysis = heat production → destruction of the target

* is the basis (concept) for all laser-tissue interactions:

1. The goal is to deliver a (WL) that is specifically absorbed by the chromophores (water, Hb, or melanin) inducing heat buildup and → destruction of that target
2. In an ideal situation, the WL would have little or no absorption by surrounding structures.
3. TRT: Thermal Relaxation Time: is a property when the exposure times and energy delivered (fluence) are controlled, the amount of heat buildup can be confined to the desired target with minimal or no damage to surrounding structures
4. Cooling is used to avoid damage to the surrounding structures

**Lasers in Cutaneous surgery are selected by matching of:**

A. Lasers wavelength (WL) with
B. The absorption spectrum of a desired skin targets: (Melanin, HB or Water)
   - Continuous, Pulsed, Repetitively pulsed

**Side effects of laser:**

1. Hypertrophic scarring: the most common
2. Pigmentary changes: the most common
3. Infection is possible
4. Pain is possible
5. Lack of efficacy is possible

**Main indications in Laser therapies:**

1. Hair removal in hirsute: Hair Melanin is the target
2. Pigmentation, Melasma & Tattoo: Melanin is the target
3. Vascular lesions: Hb is the target
4. Warts & Tumours: by Ablation (cutting): Water is the target
5. Scars & wrinkles:
6. Excimer laser for: Psoriasis & Vitiligo

**Types of Lasers:**

1. Both Lasers Argon & Cooper Vapor/Cooper Bromide Laser Have been Replaced by other lasers
2. Excimer lasers
   - The first excimer laser was invented in 1970
   - 308 nm
   - Dermatological treatment is for:
     - Psoriasis
     - Vitiligo
3. KTP (Potassium Titanyl Phosphat) Laser
   - Produces a visible green beam of 532 nm.
   - For: Vascular, superficial pigmented & red tattoos
   - The KTP laser is actually an Nd:YAG laser which emits a WL of 1064 nm.
   - The beam is passed through a crystal of KTP which reduces the WL by 50% producing the 532nm WL.
   - can be Q-switched (quality switched), emitting a beam in the range of 10 to 50 ns
4. Pulsed Dye Laser: (PDL):
   - Was the first laser developed to specifically take advantage of the theory of selective photothermolysis
   - The laser medium is a rhodamine dye which initially was developed to deliver a wavelength of 577 nm, coinciding with a specific Hb absorption peak. (in the current generation of PDL the WL has evolved to be 595 nm)
   - Indications: PDL for the treatment of
     - Vascular lesions: The is extremely useful
     - Port-wine stains, B. Telangiectasias,
     - Erythemato-telangiectatic rosacea,
     - Hemangiomas.
     - Warts: PDL has been effectively used

5. Ruby Laser (Q-Switched):
   - Emits a red 694 nm beam
   - The 1st laser developed
   - Indications of Ruby Laser:
     1. Tattoos with black, blue, and green pigment. } Effectively
     2. Macular pigmented lesions, such as lentigines, ephelids & nevus of Ota } treated
     3. Café-au-lait macules, } respond, but
     4. Becker nevus, } the success
     5. Postinflammatory pigmentation } is unpredictable
     6. Treatment of melasma is very disappointing, with some patients improving, some showing no response, and others with temporary worsening.
   - SEs of Ruby Laser:
     - Crusting (immediate, takes approximately 7 to 10 days to resolve.
     - Both Hypo- and Hyper-pigmentation (Longer-term)

6. Alexandrite Laser (Q-Switched):
   - Uses the semiprecious stone (alexandrite) as the active medium
   - Long WL (755nm) penetrates deeply into dermis with absorption by blue, black, and green tattoo pigment.
   - Shows a similar therapeutic profile to the Q-switched ruby laser
   - One advantage, however, is the ability to deliver the alexandrite laser at 10 pulses/s, allowing for more rapid therapy compared with the single pulse/s delivery with the ruby laser.
   - Disadvantages include a smaller beam diameter and less power.
   - Lasers effectively treat tattoos are the:
     - Q-switched alexandrite laser
     - Q-switched ruby and
     - Q-switched Nd:YAG lasers

7. Neodymium:Yttrium-Aluminum-Garnet Laser (Nd: YAG) laser can be used in 3 modes:
   a) Continuous wave } These modes emit an invisible
   b) Q-switched } near-infrared beam (1064nm)
   c) Doubled frequency (KTP)
   - Because of the longer WL, the Nd: YAG laser penetrates much deeper and therefore is useful in treating more deeply seated or thicker lesions compared to shorter wavelength lasers
Indications of (Nd: YAG) laser

1. Black and Blue tattoo & Nevus of Ota: Q-switched mode is highly effective
2. Red tattoo & superficially pigmented lesions: (doubled frequency mode, the green 532 nm beam)
3. hair removal in darkly pigmented patients: By extending the pulse duration
4. vascular lesions, especially larger and deeper vessels. Hemangiomas, vascular malformations such as port-wine stains, and deeper larger caliber vessels: as Hb has a small peak at 1064 nm, the longer pulsed Nd: YAG laser has been used

8. Erbium:Yttrium-Aluminum-Garnet Laser
- The Er:YAG laser emits an invisible near-infrared beam of 2940 nm, resulting in significantly more efficient absorption (15 times) by water, and a more explosive ablative effect, as compared to the CO2 laser. As such, the Er:YAG laser results in tissue ablation with less surrounding thermal damage.
- In addition, this wavelength is close to a collagen absorption peak, thus allowing for collagen ablation much more efficiently than the CO2. The decreased thermal injury and collagen ablation is an advantage for treatment of scars, photodamaged skin, and rhytids (Fig.38-7). Some maintain that healing may be slightly faster, with less risk of prolonged erythema and scarring (especially below the jawline).
- Nonetheless, depth of injury is the primary determinant for prolonged erythema and scarring. The decreased thermal damage can result in poor hemostasis with the Er:YAG laser. To address this limitation, certain systems have a coagulation feature to limit the amount of intraoperative bleeding. In addition, the collagen-tightening effect may not be as pronounced as with the CO2 laser. However, when similar clinical injuries and depth are achieved, studies have shown that the Er:YAG and CO2 lasers have comparable photorejuvenating effects, and similar postoperative healing times and complication profiles.

9. Carbon Dioxide Lasers: CO2 laser
- Emits an invisible infrared beam of 10,600 nm and can be used in continuous-wave or super-pulsed mode.
- Water nonselectively absorbs laser energy, turning it instantly into steam, and producing ablative and thermal damage.
- Used in the superpulsed mode, the laser beam can be delivered in short bursts, allowing thermal destruction of the epidermis and papillary dermis while limiting deeper thermal damage.
- Delivery in this mode is more uniform and markedly faster when the optomechanical scanner is employed.
- Super-pulsed CO2 lasers are extremely useful in the treatment of
  - Actinic damage and
  - Photoaging
- The thermal injury causes conformat changes within the collagen, leading to clinical tightening. As such ablative laser resurfacing is extremely effective at improving wrinkling, scarring, and skin tone.
- SEs include
  - postinflammatory pigmentary changes, scarring
  - textural changes, prolonged erythema
- In addition, patients must be educated regarding the morbidity of the postoperative course and prolonged recovery associated with ablative resurfacing.
- Used in the quasi continuous-wave mode, it is an excellent therapeutic choice for very large planter and periungual warts, which have failed to respond to routine office modalities.
- Both a cutting mode and a defocused ablative mode can be used with these systems to effectively excise the visible verrucase and treat any residual human papillomavirus in surrounding skin. Thr CO2 laser is also an excellent treatment option for ear lobe keloids but may not be as successful for keloids elsewhere.
- Other benign lesion amenable to CO2 laser ablation include xanthelasma, rhinophyma, and syringomas. Various malignant and premalignant lesions also are effectively treated by laser ablation, including actinic chelitis, and superficial basal and aquamous cell carcinomas
Lasers for Hair Epilation

1. Alexandrite          755nm
2. Diode                   800nm
3. Ruby                    694nm
4. Nd-YAG              1064nm

Lasers for Vascular lesions

1. Pulsed Dye           585nm
2. Nd-YAG               1064nm
3. Nd-YAG                 532nm
4. Diode                     800nm

Lasers for pigmented Lesions

Dermal

1. Q-switched Ruby       694nm
2. Q-Switched Alexandrite 755nm
3. Nd-YAG                1064nm

Epidermal

1. Pulsed Dye           510nm
2. Nd-YAG               532nm

Laser Hair Removal

- Laser hair removal is widely used for the permanenet reduction of hair and this is one of the most popular laser procedures performed.
- Most lasers for hair removal target the melanin within the follicle
- White, blond, and grey hairs generally respond poorly.
- As melanin is the target for these lasers, care must be taken in treating more darkly pigmented patients to avoid epidermal damage. In this patient population, the longer pulsed Nd:YAG laser has allowed safe treatment with fewer complications.
- As hair is the target, pts must avoid waxing, electrolysis, or plucking of hair prior to laser hair removal.
- Shaving prior to laser treatment is acceptable (and is mandatory immediately prior to treatment to avoid epidermal injury) and will not interfere with efficacy.
- It appears that only hairs in the anagen growth phase are permanently injured. Therefore, sufficient time must elapse between treatments for hair to regrow and provide an appropriate chromophore for subsequent laser treatment, generally 8 to 12 weeks.
- Lasers used for hair removal can produce a significant reduction in both hair and papules/pustules in patients with pseudofolliculitis barbae
  1. ruby (long pulsed)
  2. alexandrite (long pulsed)
  3. diode (long pulsed)
  4. Nd:YAG lasers (long pulsed)
  5. IPL.
- Effective laser treatment of white and blond hairs remains a challenge.
Ablative Laser Resurfacing

- Both CO2 and erbium: YAG (Er:YAG) lasers are absorbed by water. Since water makes up 72% of the skin, they effectively ablate the skin to varying depths depending on the energy delivered.
- Indications:
  - Warts
  - Adnexal tumors
  - Skin cancers
- Early systems employed a continuous wave mode of emission, which lead to a greater degree of thermal damage and risk of scarring. Newer high energy ultra-pulsed and computerized scanning systems have allowed a greater degree of control with laser ablation, resulting in more predictable outcomes.

Laser Beam Hazards

- Eye hazard, Skin hazard

Laser Hazard Classification Accessible Emission Limit (AEL)

- Laser systems are classified on the basis of the:
  - Laser radiation accessible outside the laser during the intended use
  - Human eye or skin is possible to be exposed to the laser radiation
- Class 1 laser: Low power; Considered safe
- Class 2 laser: Eye protection afforded by the eye blink response
- Class 3 laser: Medium power; Hazard to the eye from direct exposure
- Class 4 laser: High power; Hazard to the eye and skin from direct and reflected exposure; Fire hazard

Beam & Non-Beam Hazards

I. Beam Hazards: Skin Hazard

- Visible and infrared high-power lasers can cause permanent skin damage or damage to underlying organs
- Skin response to laser exposure are:
  1. Mild to severe reddening
  2. Blisters and charring
  3. De-pigmentation
  4. Ulceration
  5. Scarring

II. Non-Beam Hazards:

- Fire: Ignition of materials can occur from direct or intense reflected or scattered beams
- Electrical: Most deaths caused by lasers are caused by electrocution. Laser capacitors can retain high energy charges even when the power is off
- Laser-generated airborne contaminants:
- Chemical fumes, aerosols of biological contaminants including viable viruses and other biohazards can and do exist in the laser plume
- Chemical: Laser dyes, solvents and gases used may be toxic, explosive or carcinogens

Maximum Permissible Exposure: MPE: is Irradiance (Radiant Exposure) to which a person can be exposed without hazard to eye or skin may cause discomfort

- depends on the following parameters:
  - Laser wavelength
  - Duration of exposure
  - The MPE for eye exposure is much lower than the MPE for skin
Protective Eyewear

- The protection wavelength(s) and the corresponding attenuation are scribed on the eyewear
- The attenuation is given in Optical Density (OD). An OD of 4 means that the irradiance of the beam passing through the eyewear is attenuated by 10,000 times

Intense Pulse Light (IPL):

- Is quite different from a laser.
- A computer generated system, which emits a broad spectrum of light WLs, photons from 500 to 1300 nm.
- Special cut-off filters are used to block out WLs of light below the filter number selected and allow only those WLs of light above the filter number to pass through.
- This makes the IPL system versatile. Once a photon is absorbed by a chromophore, heat is released.
- It is the release of heat by the photon, around and within the microenvironment of the target chromophore, that must result in biological damage to the target and hopefully its disappearance.
- The released heat results in inflammation and injury to the pigmented lesion by the macrophages of our immune system. By incorporating the higher wavelengths with this system you can now treat darker skin types and Class I and Class II wrinkles, as well as treat leg veins.
- When using the higher filters you will see improvement in the wrinkles, pore size and skin texture.
- The long wavelengths create a subclinical dermal inflammation that stimulates the conversion of a fibroblast into a fibrocyte.
- Overtime, activated fibrocyte produces new collagen. At the same time, existing collagen will shorten.
- The new collagen is organized into tight fibrils. Accumulation of new dermal collagen over the course of several treatments results in a thickening of the dermis and an apparent softening of the wrinkle, textural irregularity or pore size.
- There are many IPL machines that preform very efficiently, however, in my opinion, the upgraded Vasculight Plus (HR), is the most effective and versatile device currently available using the Intense Pulse Light technology.
- This is a proven and effective treatment that you can bring to your practice with confidence. It truly does what it says it does. It works! Patients will see results and be happy. A happy patient can generate on average four more patients.

Intense Pulsed Light: (IPL)

- is a device that uses a flashlamp which emits a noncoherent broad spectrum of light (from 400-1200 nm) at various pulse durations and intervals.
- By employing filters to eliminate the lower wavelength, light from 560 nm and above can be used to treat various cutaneous conditions.
- has the advantage of treating more than one specific chromophore at a time.

IPL has been used for the rejuvenation of photoaged skin. Weiss et al demonstrated significant improvement in telangiectasias, pigment, and skin texture of the face, neck, and chest with IPL. IPL has been combined with topical aminolevulinic acid for photodynamic rejuvenation. By using IPL as the activating light source, patients benefit from the treatment of actinic keratoses as part of photorejuvenation. IPL has also been effectively used for hair removal.