Laser and Device Treatment for Facial Pigmentation
What’s new? What’s Old and Still Works?

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Relevant Disclosures: Consultant and Investigator for Hologic, Cutera, Galderma, Asclaris
Clinical Practice in the USA

- **Photodamage** - This is the most common cosmetic problem in the US market. It is also a significant issue in parts of the world where sun exposure is an important part of daily life. While this is a major problem for lighter skin types, it is also a significant issue for darker skin types.

- **Melasma** - In most practices, this is the second most common pigmentary complaint. It has significant quality of life implications.

- **Café au lait**

- **Nevus of Ota and Hori’s Nevus – The role of picosecond devices**
Photodamage: The most common problem in the rejuvenation space

- Fine and coarse wrinkles
- Mottled hyperpigmentation and lentigines
- Solar elastosis
- Telangiectasia
Medical therapy can only accomplish so much!
Device options for treating this problem

- IPL
- Fractional ablative and non-ablative; CO2, erbium, 1927nm, 1540nm, 1550nm, 1440nm, 1470nm
- Q-Switched Nd:YAG, Alexandrite and ruby lasers
- Millisecond high power 532 nm KTP laser.
- Picosecond Alexandrite and Nd:YAG lasers with the flat or the fractional optic
Many devices are available with different cutoff filters, different cooling.

This technology can selectively target both the abnormal pigmentary component and vascular component.

Often 1-2 treatments can result in a significant improvement.

These devices can be tricky in dark skinned individuals or people with a tan!

These devices have many different price points and generally have low maintenance costs.
IPL Spectra & Melanin

Comparable absorption by melanin
IPL – Pigment and redness
IPL Pigmentation – 1tx
Melanin Index Meter

**Specs**
- LED Light Source
- Wavelengths: 640 nm, 700 nm, 910 nm
- Melanin Index Range: 0-99
- Measurement Time: Less than 1 second
- Dimensions: 1.2” x 2” x 8.5” (3 cm x 5 cm x 21.5 cm)
- IPL, diode, Alexandrite and 1064NdYAG inadvertently targets surrounding melanocytes
- Excessive absorption of light causes post-inflammatory hypopigmentation +/- scarring
- Duration depends on intensity of inflammatory process
Ablative Devices

- CO2 and erbium - Fully ablative lasers can achieve a remarkable improvement, but with significant downtime for up to 2 weeks

- Fractional ablative lasers – With multiple treatments can only, sometimes, achieve the results seen with 1 treatment of a fully ablative laser
Ablative CO2 – 1 treatment
Fractional Non-ablative Devices

- Many wavelengths to choose from: 1320nm, 1440nm, 1470nm, 1540nm, 1550nm, 1927nm
- Only 1927nm coagulate epidermal cells containing melanin. The others primarily wound collagen in the dermis.
- There is a fractional erbium and 1470nm combination device which can target epidermal cells with pigment pigment and wound the dermis.
Hybrid fractional laser; 1470nm diode, 2940nm erbium laser

24 hours post treatment
Hybrid fractional laser; 1470nm diode, 2940nm erbium laser

FIGURE 1. (A) 53-year old Hispanic female, Fitzpatrick Skin Type III with dyschromia on face. (B) Same patient post 2 laser treatments with the hybrid fractional laser done one month apart for dyschromia.
Hybrid fractional laser; 1470nm diode, 2940nm erbium laser

**FIGURE 4.** Before treatment (left) and after two treatments (right) in a Caucasian subject.
Non-ablative Fractional Resurfacing with the 1927 nm Thulium Laser is an Effective, Well-tolerated Treatment for Actinic Cheilitis


Histology of non-ablative fractional resurfacing using the Thulium 1927nm laser.
Thulium 1927nm laser treatment for photodamage

**FIGURE 2.** Independent evaluator-rated clinical improvement in lentigines, ephelides, and overall appearance for facial treatment (n=37). 95% confidence intervals (CI's) included for all data sets. Quartile improvement scale, 0-4: 0-none, 1-minor/mild, 2-moderate, 3-marked, 4-very significant.

Subjects at the one-month follow up visit (front view: $P<0.0001$, $P<0.0001$, $P=0.0002$, respectively; left view: $P<0.0001$ for all), with mild improvement maintained out to the three-month follow up visit (front view: $P=0.0002$, $P<0.0001$, $P=0.0002$, respectively; left view: $P=0.0006$, $P=0.0005$, $P=0.0008$, respectively; Figure 2).
Choose a device that works for your practice! What is your patient population? What type of climate do you work in? What sort of down time will your patients tolerate?

IPL devices have many advantages and can target multiple problems with a good price point but can be tricky in tan and dark skinned patients.

There are many hybrid or two wavelength devices that can address the wrinkling with more aggressive setting! You can also combine your devices either at the same time or separately.
Photodamage in patients of color, Skin Types IV-VI or Patients with Tan

- The reality of PIH is often an overriding concern in patients of color.
- Treatments that focus on the epidermis without significant wounding at the dermal/epidermal junction are better tolerated.
- Devices
  - IPL or millisecond devices that target melanin with a narrower margin of safety than the following devices.
  - Q-Switched Nd:YAG
  - Picosecond lasers best margin of safety.
Picosecond Devices

- 755nm Alexandrite with the flat and fractional optic
- 532nm/1064nm Nd:YAG with flat and fractional optic

✓ The flat optic in both devices are using the thermal and photomechanical properties of their devices in the picosecond realm to target pigment. Generally low doses are used with multiple passes

✓ The fractional optic results in a localized region laser induced optical breakdown (LIOB) which selectively damages the epidermis without significant damage to the dermis. The 532nm/1064nm Nd:YAG also can target the superficial vascular plexus and result in transient hemorrhage.
Flat Optic

755nm
0.7J/cm² ; 6mm spot
Picosecond Alexandrite for lentigenes – Flat optic
2.83J/3mm spot size

Before

Post 1 Tx, 1 month

Photo Courtesy Of Shamshik Shin
Evaluation of the safety and efficacy of the dual wavelength picosecond laser for the treatment of benign pigmented lesions in Asians

Evaluation of the safety and efficacy of the dual wavelength picosecond laser for the treatment of benign pigmented lesions in Asians

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Fractional Delivery of Light from Picosecond Lasers

- Diffractive Lens Array: 755 nm Picosecond Alexandrite Laser
- Holographic Optic: 532 nm, 1064 nm Picosecond Nd:Yag
- Refractive Lens Array: 532 nm, 1064 nm Picosecond Nd:Yag
Fractional 755nm picosecond Alexandrite

Fluence distribution in the treatment plane on the skin surface. Treatment spot size 6mm, average fluence setting 0.71 J/cm². 70% of total energy is delivered through micro spots; remaining 30% results in low fluence background; less than 10% of the tissue is exposed to high fluence.
The LIOB Story

Process of vacuole formation in the epidermis:

A. A high intensity portion of the laser beam created by the diffractive lens array irradiates a region of the skin. A seed electron is ejected from an absorber (melanin)

B. The number of free electrons grows in an avalanche process.

C. Electron plasma density increases absorbing energy from the beam

D. The laser beam terminates leaving a hot plasma ball. The plasma ball heats the surrounding tissue above boiling temperature. Steam expansion creates a vacuole in the epidermis containing cellular debris
Steam Bubbles in the Skin
Skin Type = VI, MI = 95
Melanin Index (MI): 23, Skin Type IV
Picosecond 755nm (In-vivo)
Treating photodamage in skin types IV-VI and lighter skin types with a tan

- Fractional picosecond devices 755 nm Alexandrite vs. 532nm, 1064mn Nd:Yag
Photo Damage: Picosecond Alexandrite + Fractional Optic
Mottled Hyperpigmentation – Picosecond Alexandrite with the Fractional Optic

Baseline

Post 1 Tx

Courtesy of Lisa Espinoza, MD
Acne Scars – Picosecond Alexandrite laser with diffractive lens array x 3 Passes
Brazilian Skin Type: IV MI:27

Baseline

Immediately Post 1 Tx
Acne Scars – Picosecond Alexandrite laser with diffractive lens array
Brazilian Skin Type: IV MI:27

Baseline

1 month Post 4 Tx
Acne Scar: Picosecond Alexandrite laser with diffractive lens array

Baseline

Post 3 Tx
Photodamage with mottled hyperpigmentation
2 Treatments with fractional 755 optic in the summer!
Fractional 1064nm with Holographic Optic

2.1 mJ/dot MI 24 ST IV

1.3 mJ/dot MI 30 ST IV

1.3 mJ/dot MI 11 ST II
Fractional 755nm with Diffractive Lens Array

10mm - 0.25J/cm² MI 30 ST IV

8mm - 0.4J/cm² MI 30 ST IV

6mm - 0.71J/cm² MI 30 ST IV
523nm/1064nm Nd:YAG Picosecond Holographic Optic

24hrs post Tx 3

755nm Picosecond Alexandrite w/diffractive lens array

<table>
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<tr>
<th>Hand Piece Type</th>
<th>Fluence (J/cm²)</th>
<th>Spot Size (mm)</th>
<th>Rep Rate (Hz)</th>
<th># of Pulses</th>
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<tr>
<td>532</td>
<td>0.6</td>
<td>6</td>
<td>5</td>
<td>846</td>
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<tr>
<td>1064</td>
<td>1.3</td>
<td>6</td>
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<tr>
<td>755 focus</td>
<td>0.71</td>
<td>6</td>
<td>10</td>
<td>3085</td>
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Laser Interaction Modeling

- Laser induced optical breakdown (LIOB) in the epidermis leads to epidermal voids.
- LIOB is predicated on seed electrons generated by laser heating of epidermal chromophores.
  - Thermionic ionization of melanin supplies the seed electrons for LIOB.
  - Wavelength dependence of melanin absorption determines threshold fluence for seed electron generation and LIOB.
- Capillaries in the reticular dermis are exposed to fluence corresponding to the LIOB threshold or higher.
  - Blood absorption of laser energy in the dermal capillaries leads to wavelength and skin type dependent temperature rise.
  - Hemorrhaging avoidance margin defined as difference between calculated temperature rise and blood coagulation temperature rise.

<table>
<thead>
<tr>
<th>Wavelength, nm</th>
<th>532</th>
<th>2.4:1</th>
<th>1064</th>
<th>16:1</th>
<th>755</th>
<th>54:1</th>
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<td>Melanin abs, cm(^{-1})</td>
<td>555</td>
<td></td>
<td>50</td>
<td></td>
<td>163</td>
<td></td>
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<tr>
<td>Blood abs, cm(^{-1})</td>
<td>235</td>
<td>3.2</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Epid. Melanin %</td>
<td>2%</td>
<td>15%</td>
<td>43%</td>
<td>2%</td>
<td>15%</td>
<td>43%</td>
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<tr>
<td>LIOB Thresh, J/cm(^2)</td>
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<td>2.7</td>
<td>2.6</td>
<td>31</td>
<td>30</td>
<td>29</td>
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<tr>
<td>Blood Temp rise, ºC</td>
<td>172</td>
<td>105</td>
<td>40</td>
<td>28</td>
<td>25</td>
<td>22</td>
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Fractional Picosecond Alexandrite w/fractional optic—Neck and Face photodamage

Pre 1 month post 5 tx
Epidermal injury and subsequent necrosis leads to cytokine release and delayed inflammation, resulting in dermal remodeling.

♦ = cytokines
How do they compare for skin types I-III without Tan?

- IPL = PDL = 532nm high power for Telangiectasia
- IPL > 532 nm > PDL for hyperpigmentation
- Hybrid devices or combined with fractional non-abalative for wrinkles
- Conclusion: patients with photodamage look better with 1-2 treatments with IPL than the other modalities

IPL vs PDL in treatment of facial erythema: A split-face study  
Marc Z Handler MD1,2 | Bradley S Bloom MD1,3 | David J Goldberg MD, JD1,2,4 J Cosmet Dermatol. 2017;16:450–453.

Skin Types IV-VI and lighter Skin types, Tan

- Fractional Picosecond lasers offer safety and ease of use

- IPL, Fractional Ablative and Non-ablative, 532mn devices, and Hybrid Devices can be used but with challenges
Melasma

- Melasma is one of the most challenging conditions to treat with both drugs and devices.

- The use of a Q-switched Nd:YAG in a procedure referred to as laser toning is a successful technology, but there have been cases of hypopigmentation in some patients and less consistent results in dark skinned Asians living in a sunny climate.

- Many devices have been reported to be useful in treating melasma. These have ranged from IPL to Q-switched devices to fractional non-ablative. All have been reported to work, but none reliably.


With both of these devices the flat and the fractional optics have been used to treat melasma.

The flat optic can treat the epidermal and dermal components. While a significant amount of the energy can have a photoacoustic effect, there is nonetheless a significant thermal component. This heating can sometimes cause melasma to flare.

The fractional optics can lead to LIOB formation with vacuoles in the epidermis with very little immediate heat generation.
Picosecond Alexandrite 755nm flat optic

Before

6 months after last treatment
Picosecond Alexandrite with fractional optic

- There is more melanin absorption relative to hemoglobin with this device.
- This was the first picosecond device developed and the first to introduce the fractional optic.
LIOBs at 24 Hours

Fontana Mason stain for melanin
Picosecond Alexandrite with fractional optic

Before

6 months after last treatment
Picosecond Alexandrite with fractional optic

Before

6 months after last treatment
Melasma treatments with picosecond devices

- The fractional optics appear to result in better outcomes than with the flat optic.
- A slow measured approach with 1 pass appears to result in improvement with less rebound hyperpigmentation.
- The location of the injury with these devices and the clearing seen would suggest that melasma is primarily an epidermal process! Could the pigment in the dermis be melanin in dermal macrophages?
- Even with these devices adjunctive therapies are a must with good broad spectrum sun screens!!!!
Now I can even treat melasma with the fractional picosecond Alexandrite optic in the summer!

Before

8mm, 1 pass

After 5 Tx
755nm Picosecond Alexandrite laser, 1064nm Nd:YAG laser

755nm Q-switched Alexandrite laser, 1064nm Q-switched Nd:YAG laser, 694nm Q-switched ruby laser
Café au lait macules

Figure 1. Treatment of a Coast of California (Smooth-Bordered) Café au Lait Macule on the Face

A Before treatment

B After treatment

Comparison of the pretreatment photograph (A) and the posttreatment photograph (B) shows poor clearance after 3 treatments with a Q-switched 694-nm laser.
Café au lait macules

Figure 2. Treatment of a Coast of Maine (Irregularly Bodered) Café au Lait Macule on the Thigh

Comparison of the pretreatment photograph (A) and the posttreatment photograph (B) shows excellent clearance after 3 treatments with a Q-switched 694-nm laser.
Café au Lait Macules

- Can be unpredictable to treat
- Irregularly bordered coast of Maine lesions are more likely to achieve good to excellent clearances
- Q-Switched and picosecond lasers appear best suited to treat these lesions
- Smooth border coast of California lesions may only show mild improvement with a large number of treatments
Nevus of Ota and Hori’s Nevus

- Q-switched 1064 Nd:Yag laser, 755mn Alexandrite laser, 694 Ruby laser
- Picosecond 755nm Alexandrite laser and the 1064 Nd:Yag laser
Nevus of Ota – Flat Optic

Baseline

Post 1 tx, 3 Month Follow up

Courtesy of R. Geronemus, MD
Nevus of Ota

Baseline

After 5 Tx

Courtesy of Peter Peng, MD
Nevus of Ota – Picosecond, 2.49j/cm², 3.2mm, 2.5hz

Baseline

Post 1 Tx

Dr. Henry Chan Hong Kong
Results: The 755 nm picosecond alexandrite laser showed significant improvement in Asian Nevus of Ota patients at 3 or fewer treatments with minimal adverse events.
Laser treatment of Nevi

- It is not the standard of care to treat benign appearing Nevi with lasers and light devices in the U.S.

- It is done in Asia where the instances of melanoma is fairly low with the Q-Switched and normal mode ruby laser with a number of treatments.
Post Inflammatory Hyperpigmentation

- The results are largely disappointing

- The Q-Switched ruby Nd:YAG and fractional non-ablative 1550nm have been used with some success. However, in some instances these treatment can exacerbate or cause the problem.
Facial Pigmentation, photodamage
What’s useful? What’s New?

- **Skin types I-III without a tan**, there are many devices that can rejuvenate the skin and treat facial pigmentation. You must choose what is best for the patient balancing what you are trying to accomplish with an appropriate amount of down time!

- **In darker skin types** and in **individuals with a tan** the fractional picosecond technology offers distinct advantages. There is virtually no risk of PIH and overheating side effects. It does take a number of treatments to accomplish pigment removal, but is very safe.

- **Concurrent medical therapy** is synergistic and can be used for maintenance.