Ablative Fractional Lasers

Fractional CO_2 versus Erbium: YAG

Learning objectives

- Explain the concept of **fractional** and **ablative** laser resurfacing.
- Describe why **water** is the target (chromophore) and how wavelength changes depth and heat.
- Compare **Fractional CO_2 (10,600 nm)** and **Er: YAG (2,940 nm)** in depth, thermal effect, downtime and risks.
- Select the suitable device for a given indication (deep scars vs. superficial lines / sensitive skin).
- List contraindications, post-care steps and common complications.

1. Introduction

Laser skin resurfacing removes or remodels damaged skin to improve texture, scars and wrinkles. Lasers used for this purpose are divided into **ablative** (they vaporize tissue) and **non-ablative** (they heat the dermis without removing the epidermis). The two devices in this lecture are both **ablative** lasers: CO_2 and Er: YAG. Both work by targeting **water** in the skin.

Why fractional? Older (fully ablative) resurfacing treated the whole surface at once, which caused long healing and more complications. In **fractional photo thermolysis**, the beam is split into thousands of microscopic columns called **microscopic treatment zones (MTZ)**. Healthy skin is left between the columns, so healing starts from the untouched skin and recovery is faster.

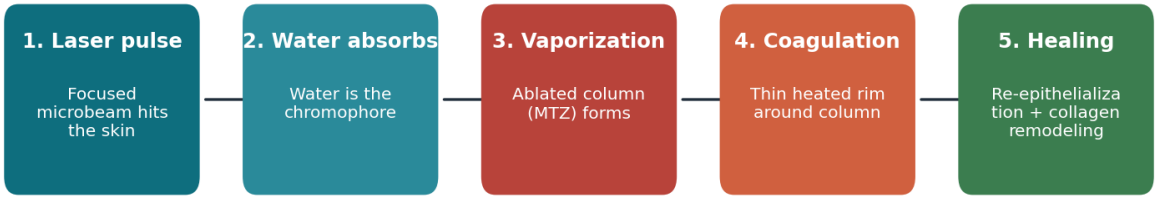

Figure 1. Sequence of events after a pulse of an ablative fractional laser (simplified).

2. Basic physics: wavelength, water and heat

Skin is mostly water, so both lasers use water as the **chromophore**. The difference is how strongly each wavelength is absorbed:

- **Er: YAG (2,940 nm)** matches the peak absorption of water. Energy is absorbed in a very thin layer, giving precise ablation with little heat spreading into the surrounding tissue .
- **CO~2~ (10,600 nm)** is also absorbed by water but much less strongly. The beam penetrates deeper and leaves a wider zone of **thermal coagulation** around each column, which stimulates collagen contraction and remodeling .
- The reported absorption coefficient of water is about **12,000 cm^{-1}** at 2,940 nm versus about **800 cm^{-1}** at 10,600 nm, and residual thermal damage is roughly up to 50 µm for Er:YAG versus 150 µm for CO_2 .

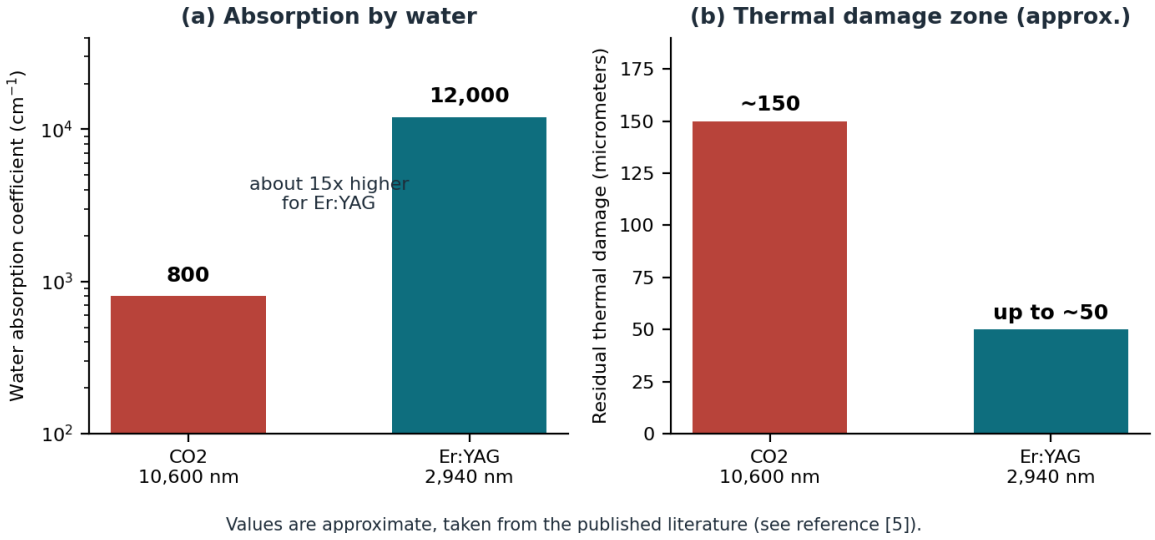

Figure 2. Absorption of water and approximate thermal damage zone (values from ref.).

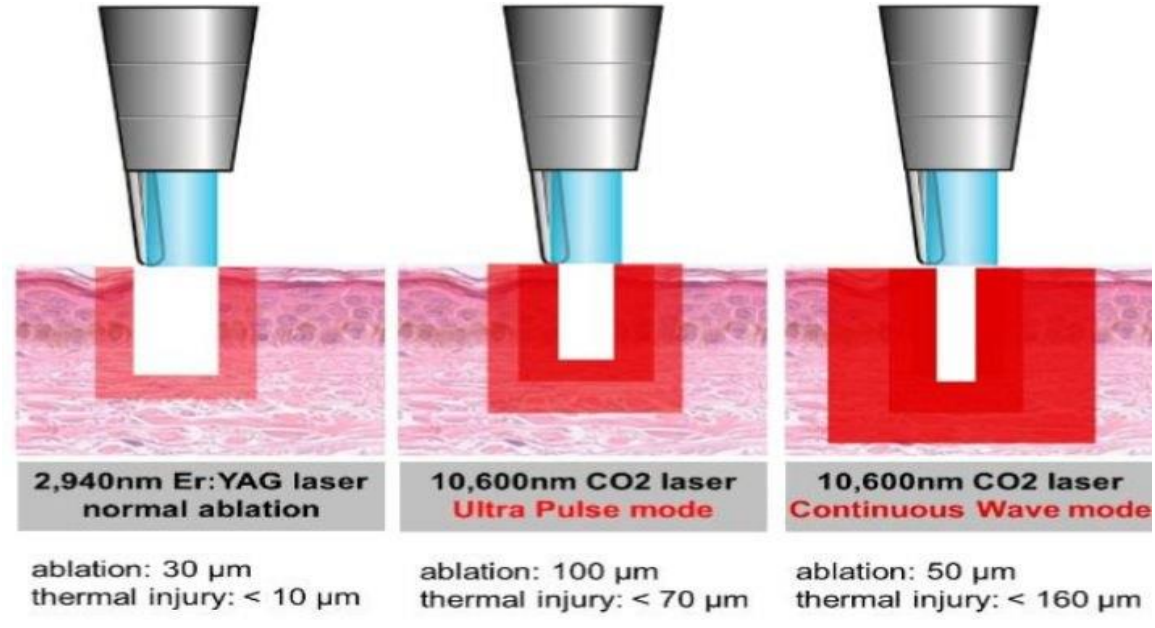

Figure 3: Impact of Pulse Modes on Thermal Coagulation

3. The two devices

3.1 Fractional CO_2 laser

- Deepest and most powerful ablative fractional laser; suitable for **deep scars and severe wrinkles** (lecture slide).
- Combines ablation with a significant coagulation rim, so it gives stronger skin tightening and collagen stimulation.
- Price of the stronger effect: longer downtime (redness, swelling, crusting) and a higher risk of prolonged erythema and post-inflammatory hyperpigmentation (PIH) .



Figure 4: CO_2 Fractional Laser

3.2 Fractional Er: YAG laser

- Less invasive; suitable for **sensitive skin and superficial lines** (lecture slide).
- More superficial ablation per pass with less thermal coagulation, so healing is shorter and there is less erythema and PIH.
- Limitation: less coagulation means less hemostasis and less collagen tightening, so deep scars and deep wrinkles may need more passes or more sessions.

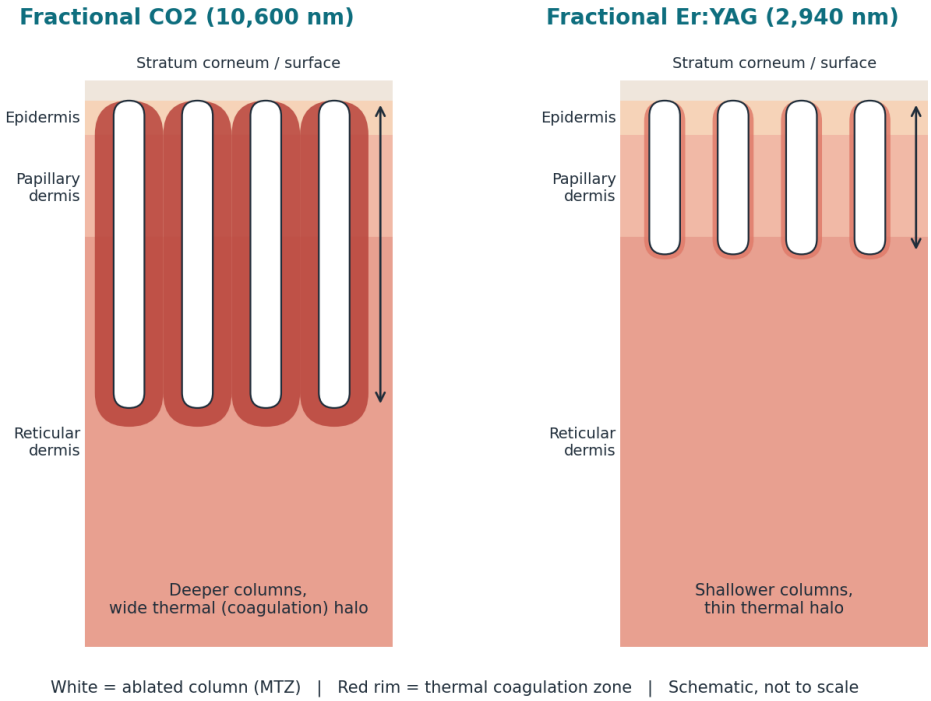

Figure 5. Schematic cross-section: CO_2 makes deeper columns with a wider thermal rim; Er: YAG makes shallower columns with a thin rim.



Figure 6: Clinical Appearance and Structure of the Laser Device

4. Side-by-side comparison

Feature	Fractional CO_2	Fractional Er:YAG
Wavelength	10,600 nm (far infrared)	2,940 nm (near/mid infrared)
Water absorption	Lower	Much higher (peak of water)
Depth / power	Deepest, most powerful	Shallower, less invasive
Thermal coagulation	Wide rim; stronger collagen tightening	Thin rim; less tightening
Hemostasis	Better (coagulation)	Weaker
Best indications	Deep scars, severe wrinkles, laxity	Superficial lines, sensitive skin, mild photoaging
Downtime	Longer	Shorter
Erythema / PIH risk	Higher	Lower
Results	Stronger and more obvious per session	Milder; may need more sessions

Table 1. Comparison compiled from refs. Actual results depend on device settings (energy, density, passes).

5. Choosing the device: quick clinical guide

- **Deep acne scars / surgical or traumatic scars, deep rhytid's, skin laxity** => usually favors **CO~2~**.
- **Fine superficial lines, mild photoaging, sensitive skin, patient who cannot accept long downtime** => usually favors **Er: YAG**.
- **Darker skin types (Fitzpatrick IV-VI)**: higher PIH risk with any ablative laser; the lower thermal damage of Er:YAG is an advantage, and test spots, conservative settings and strict sun protection are important .



Figure 4. Typical treatment pathway.

6. Contraindications and precautions

Protocols differ between centers; follow your institution's guidelines. Commonly listed points:

- Active skin infection or active herpes labialis (antiviral prophylaxis is commonly used in at-risk patients).
- History of **keloids** or hypertrophic scarring.
- Recent isotretinoin use (traditional teaching advises waiting; current practice varies).
- Recent tanning or sun exposure; pregnancy; unrealistic expectations.
- Special caution around the eyes (risk of eyelid complications) and always use proper **eye protection** for patient and staff.

7. post-care and complications

- **Expected:** redness, swelling, a sandpaper or bronzing look, and mild crusting for several days.
- **Care:** gentle cleansing, bland emollient, avoid picking crusts, and **strict sun protection**.
- **Possible complications:** prolonged erythema, PIH, infection (bacterial or herpetic), acneiform eruption, milia, and rarely scarring.
- CO_2 generally has longer healed and higher risk of erythema and PIH than Er: YAG.