

Lasers in dermatology

Magdolna Gaál M.D., PhD

Laser surgery

Lasers work by emitting a powerful beam of light, which causes a certain effect on a specific target.



Interactions of substance and laser light

- **biologic**

- photochemical reactions

- photoablation

Precise cutting and ablation with excimer laser

Ophthalmology, angioplasty

Skin resurfacing

Break of molecular bindings

- **mechanical, photoacoustic**

- Q-switched lasers, high fluence and ultrashort pulse


- Nephrolith braking

- **photothermal**



Interactions of substance and laser light

Photothermal effect

light energy  thermal energy

37°C - no damage

40-45°C – edema, enzyme induction

60°C – protein denaturation, coagulation

80°C – collagen denaturation, membrane damage

100°C - boiling, exsiccation

150°C – carbonization

300°C - vaporization

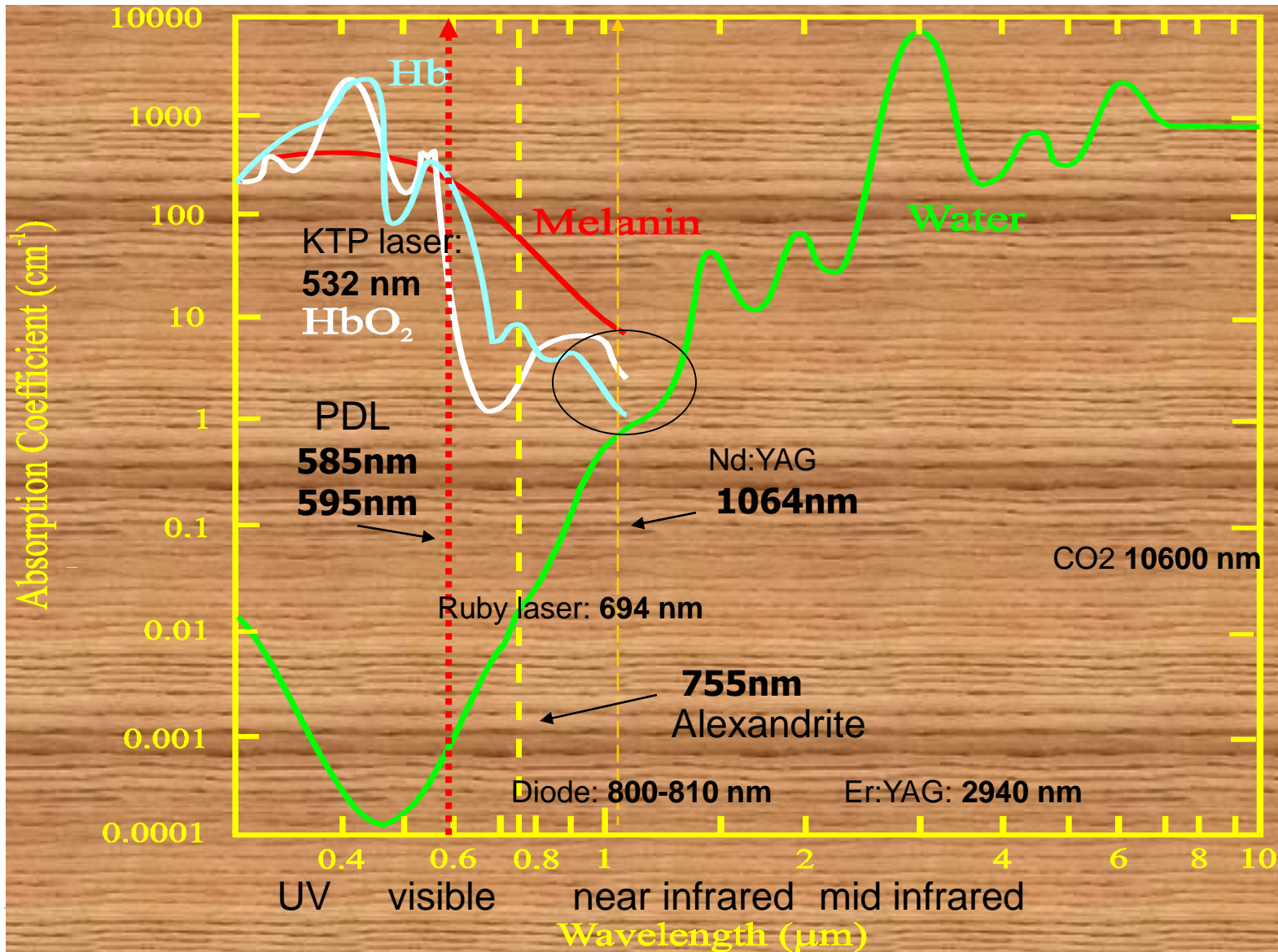


Thermal damage is influenced:


- ▶ amount of chromophores (light absorbing structures, e.g. haemoglobin, melanin, water)
- ▶ duration of the impulse (exposure time, pulse duration, pulse width)
- ▶ fluence



The four major chromophores in skin (spectrum)



Lasers in dermatology

- ▶ Generally as higher the wavelength, deeper the effect
 - ▶ Argon laser: 488 nm
 - ▶ KTP laser: 532 nm
 - ▶ PDL (pulsed dye): 585 nm
 - ▶ Ruby laser: 694 nm
 - ▶ Alexandrite: 755 nm → hair removal, pigmented lesion
 - ▶ Diode: 800-810 nm
 - ▶ Nd:YAG: 1064 nm → deeper vessels, HR, photorejuvenation
 - ▶ Er:YAG: 2940 nm → peeling (ablative)
 - ▶ CO₂: 10600 nm → vaporization (surgery)
 - ▶ Q-switched lasers (ultra short pulse): tattoo, pigment lesions
- 
- thin vessels



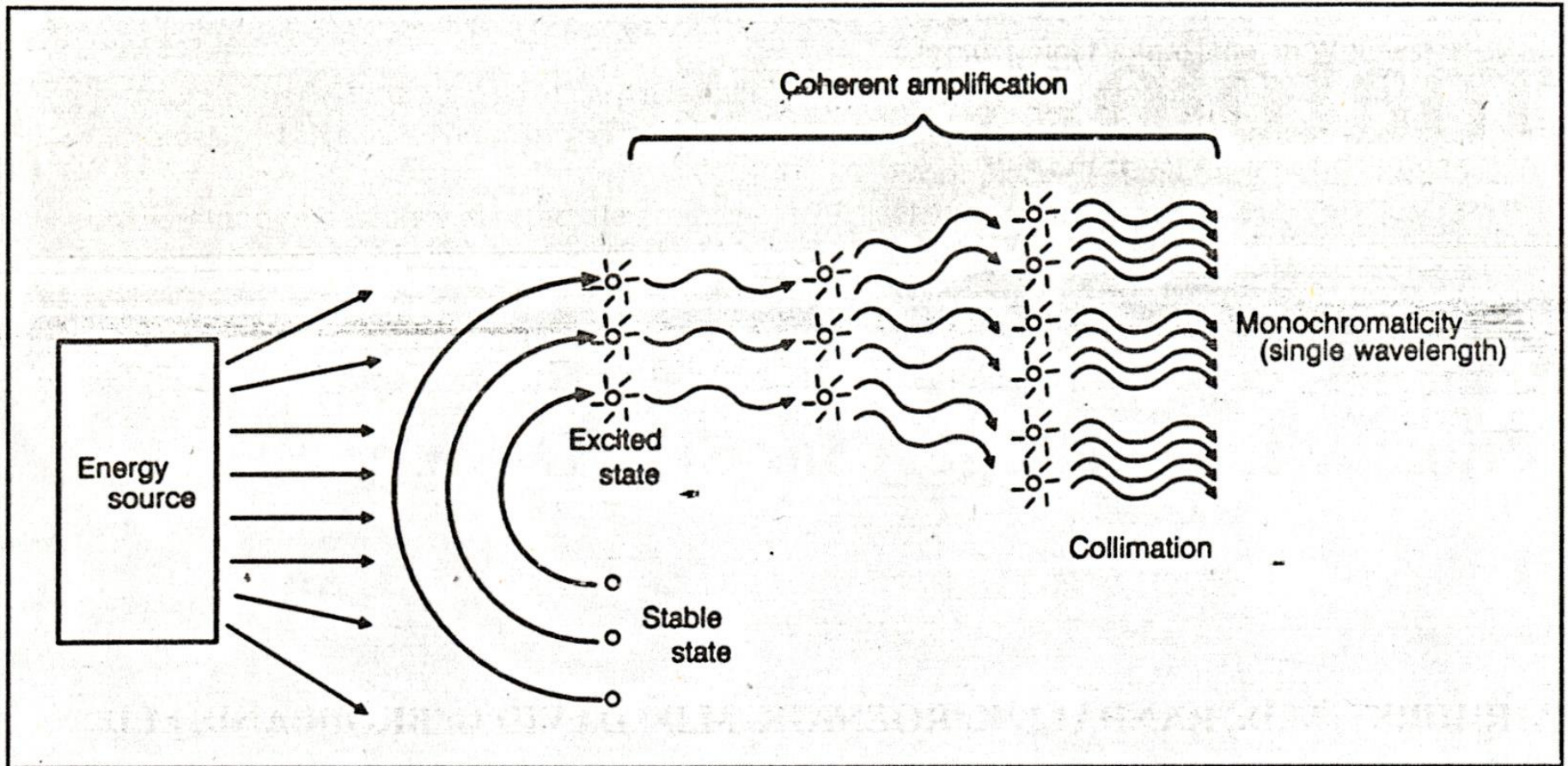
What is Laser?

- Light
- Amplification by
- Stimulated
- Emission of
- Radiation

Stimulation of a substance result in light emission when its molecules return to stable state



GENERATION OF A LASER BEAM



LASER light

- ▶ a given stimulated substance can produce light with a specific wavelength
- ▶ Monochromatic (specific wavelength)
- ▶ Coherent (photons are in the same phase)
- ▶ Collimated (parallel)



IPL (Intense pulsed light)

- ▶ Not a laser!
- ▶ Wide spectrum
- ▶ Filters
- ▶ HR: hair removal 600-950 nm
- ▶ PR: photorejuvenation 530-750 nm
- ▶ PL: pigmented lesions 400-720 nm
- ▶ VL: vascular lesions 555-950 nm
- ▶ Contact gel is required



IPL Systems

Lasers

Non-monochromatic (A band of wavelengths)

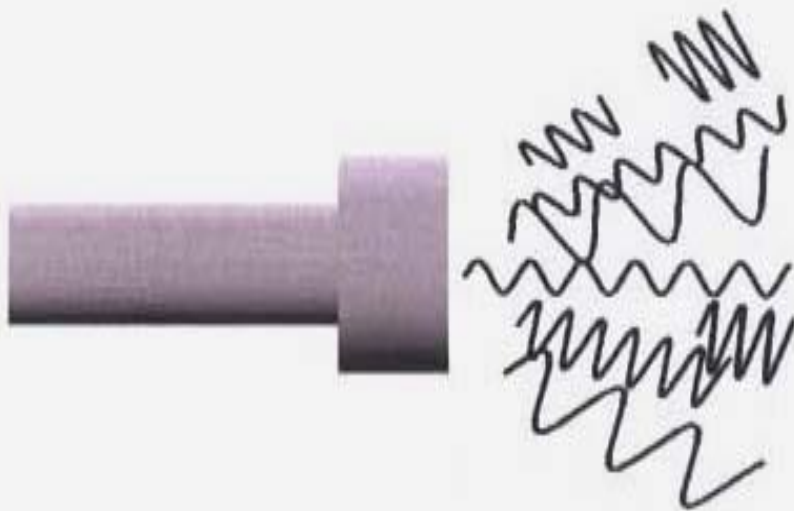
Monochromatic (Only one wavelength)

Non-Coherent (Waves are not in phase)

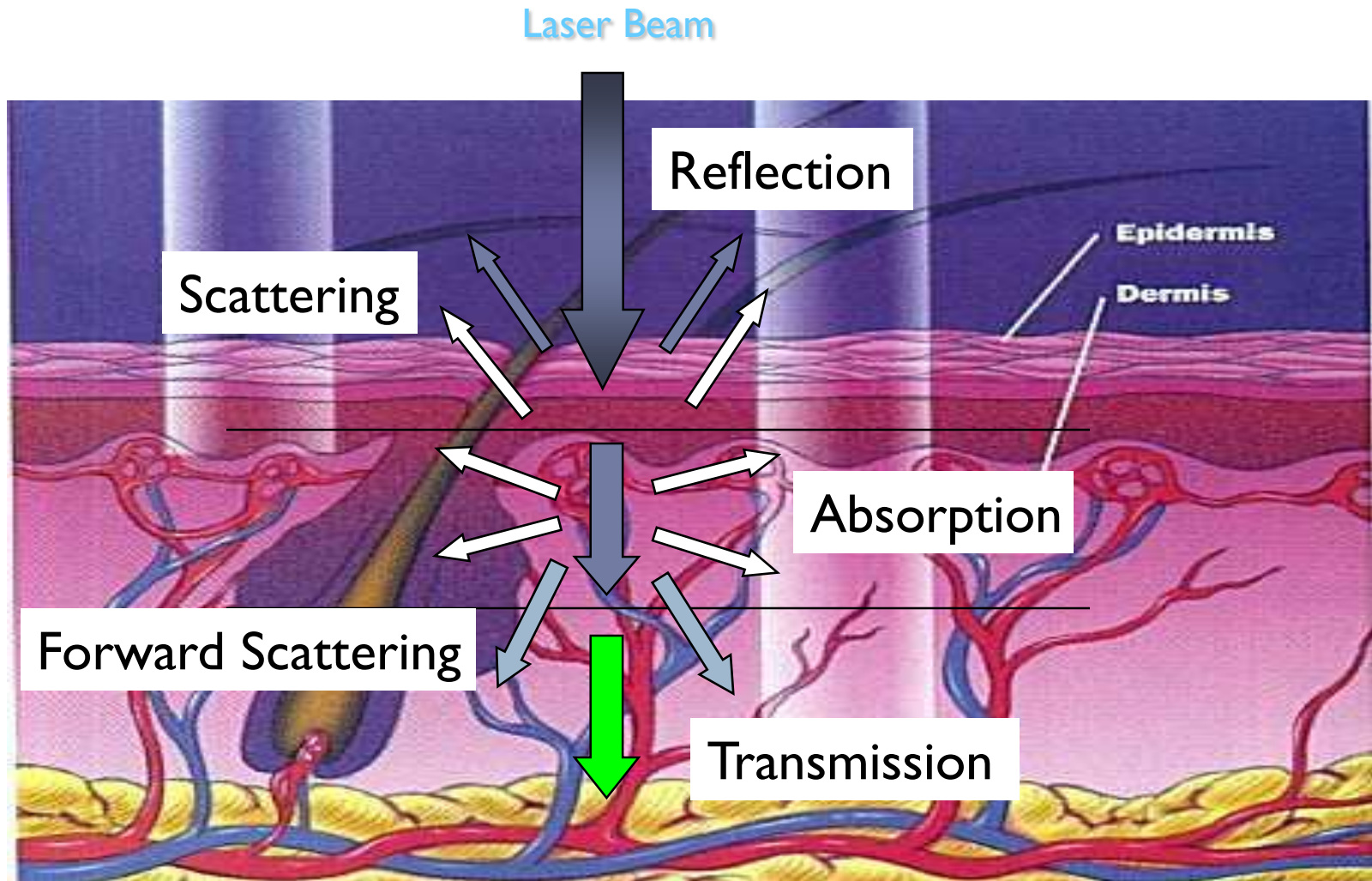
Coherent (Waves are always in phase)

Defocused light

Parallel light (Collimated)



Laser tissue interactions



Selective photothermolysis

- ▶ Controlled destruction of a targeted lesion without significant thermal damage to surrounding normal tissue
- ▶ A proper wavelength to intended tissue target or chromophore
- ▶ Shorter pulse width than the chromophores thermal relaxation time



Thermal Relaxation Time

The time necessary for the target to cool down 50%, through the transfer of its heat to surrounding tissue via thermal diffusion.



➤ Laser hair removal



Hair removal

- alexandrite, Nd:YAG, IPL
- target: the hair bulb and a stem cell area (near adhesion of m. arrector pili)
- result depends: type of laser, color and thickness of the hair shaft, skin pigmentation
- ideal patient: light skin, dark hair
- hair shaft in anagen phasis, monthly, 5-7 treatment sessions
- maintaining sessions (1-2/year)



➤ Vascular Lesions

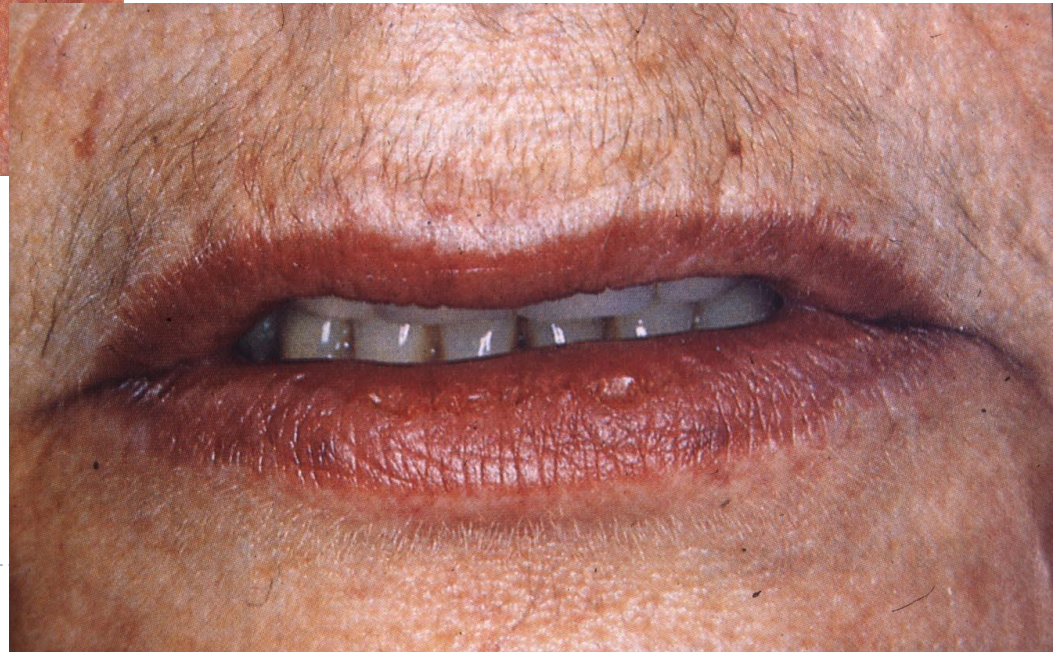
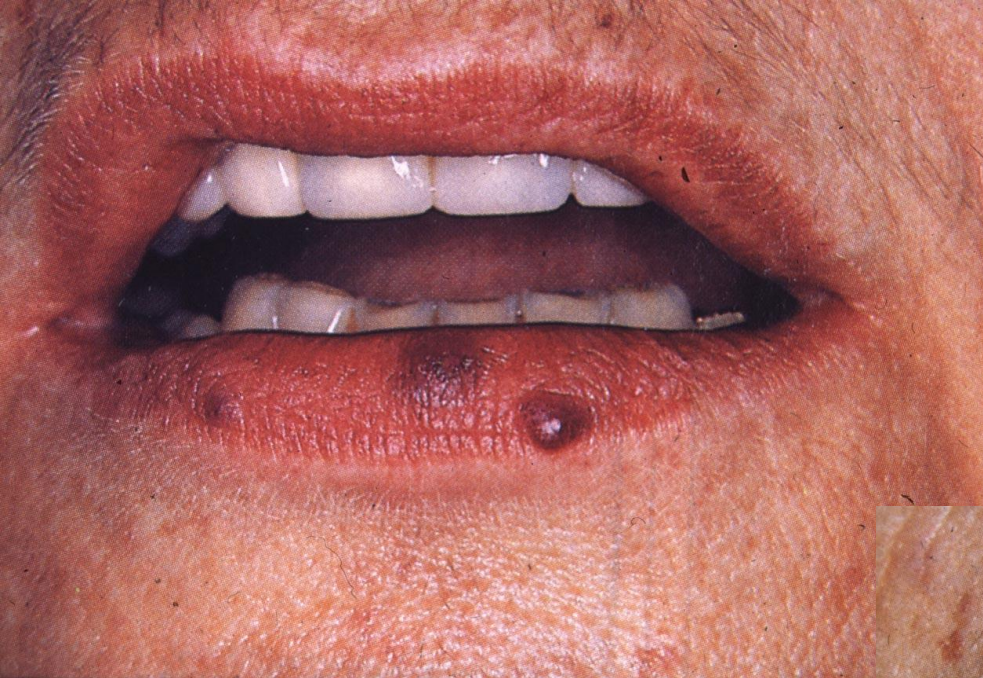


• superficial vascular lesions → dye lasers
585- 590-595-600 nm

• deep vascular lesions → Nd:YAG
1064nm



Angiomas on the lower lip: Nd:YAG laser treatment



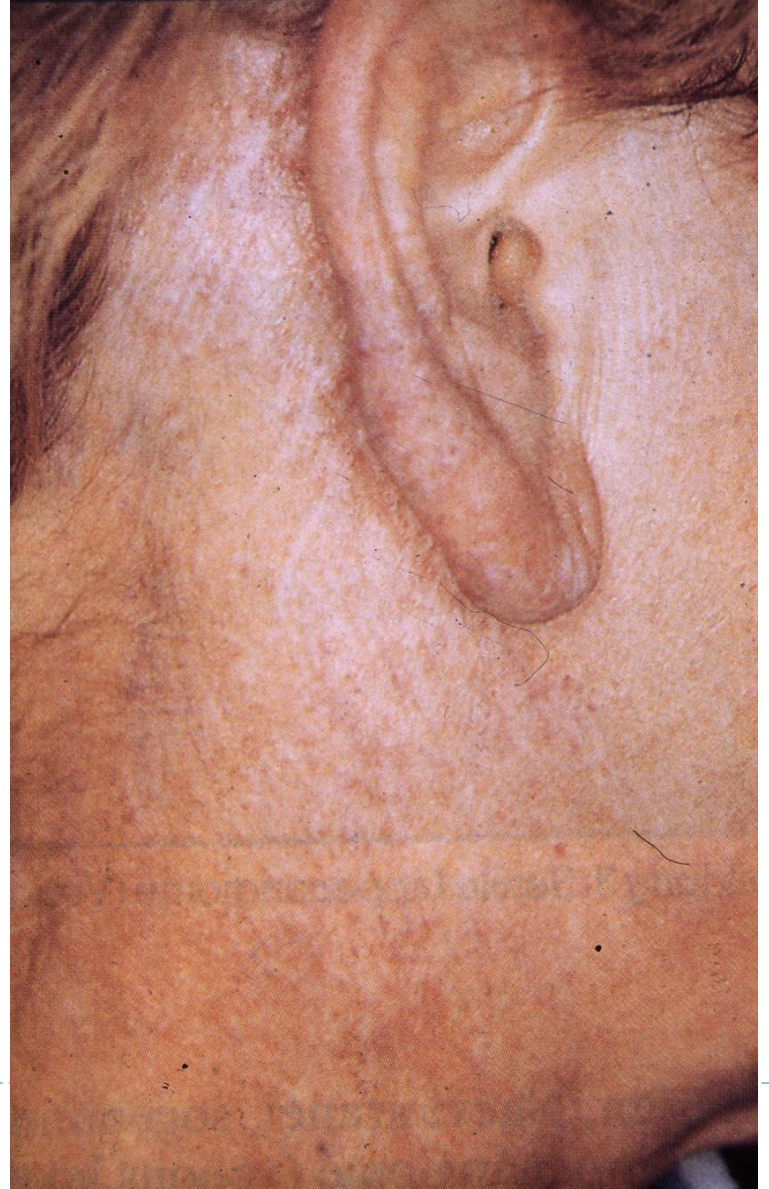
Spider angioma: treatment with Nd:YAG laser



Pulsed dye laser treatment of a cavernous angioma



Treatment of a port wine stain with pulsed dye laser



Nd:YAG – Leg Veins



Before treatment



After two treatments

Cynergy multiplex

Improving Treatment Outcomes

- ▶ By using both the 585 nm and 1064 nm wavelengths at the same session, that we can improve outcomes while minimizing adverse effect



Teleangiectasia treatment



Indications of Vascular Dye Laser

- ▶ Vascular Nevi
 - ▶ Vasc. malformations
 - ▶ Pyogenic granuloma
 - ▶ Venous lakes
 - ▶ Angiokeratoma
 - ▶ Telangiectasia
 - ▶ Angiofibroma
 - ▶ DLE
 - ▶ Seb. Hyperplasia
 - ▶ Rosacea
 - ▶ Keloids & Scars (existing & prophylactic)
 - ▶ Warts
 - ▶ Stria distinsae
 - ▶ Acne & Post Acne scars
 - ▶ Psoriasis
 - ▶ Xanthelasma
 - ▶ Rejuvenation
-



Pyogenic Granuloma



Acne Vulgaris



Pre-Treatment



Post 2-Treatments



Pulsed dye laser (PDL) treatment of psoriasis

- ▶ 585, 595 nm
- ▶ ablation of the superficial capillary bed of psoriatic lesions, reduction in the endothelial surface area and proliferation, reduction in T-lymphocyte infiltrate *Hacker, Rasmussen, Arch Dermatol, 1992*
- ▶ efficacy in plaque-type psoriasis *Erceg 2006, Bovenschen 2007*
- ▶ normalization of epidermal proliferation and keratinization *De Leeuw, 2009*
- ▶ **expression of VEGFR2, VEGFR3, E-selectin, IL23, TNF α decreased after 2 sessions of PDL** *Rácz et al, Lasers Surg Med 2010*



Efficacy of PDL in Psoriasis

before treatment

after 5 PDL treatments



PDL: 7mm spot size, 9 J/cm², pulse duration: 0.5 msec



Efficacy of PDL and Multiplex laser in Psoriasis

before treatment

after 5 treatments

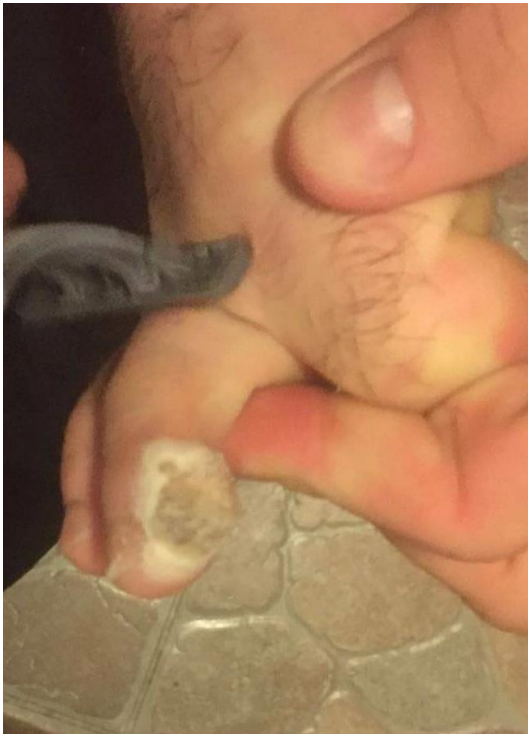


PDL: 7 mm spot size, 12 J/cm², pulse duration 0.5 ms

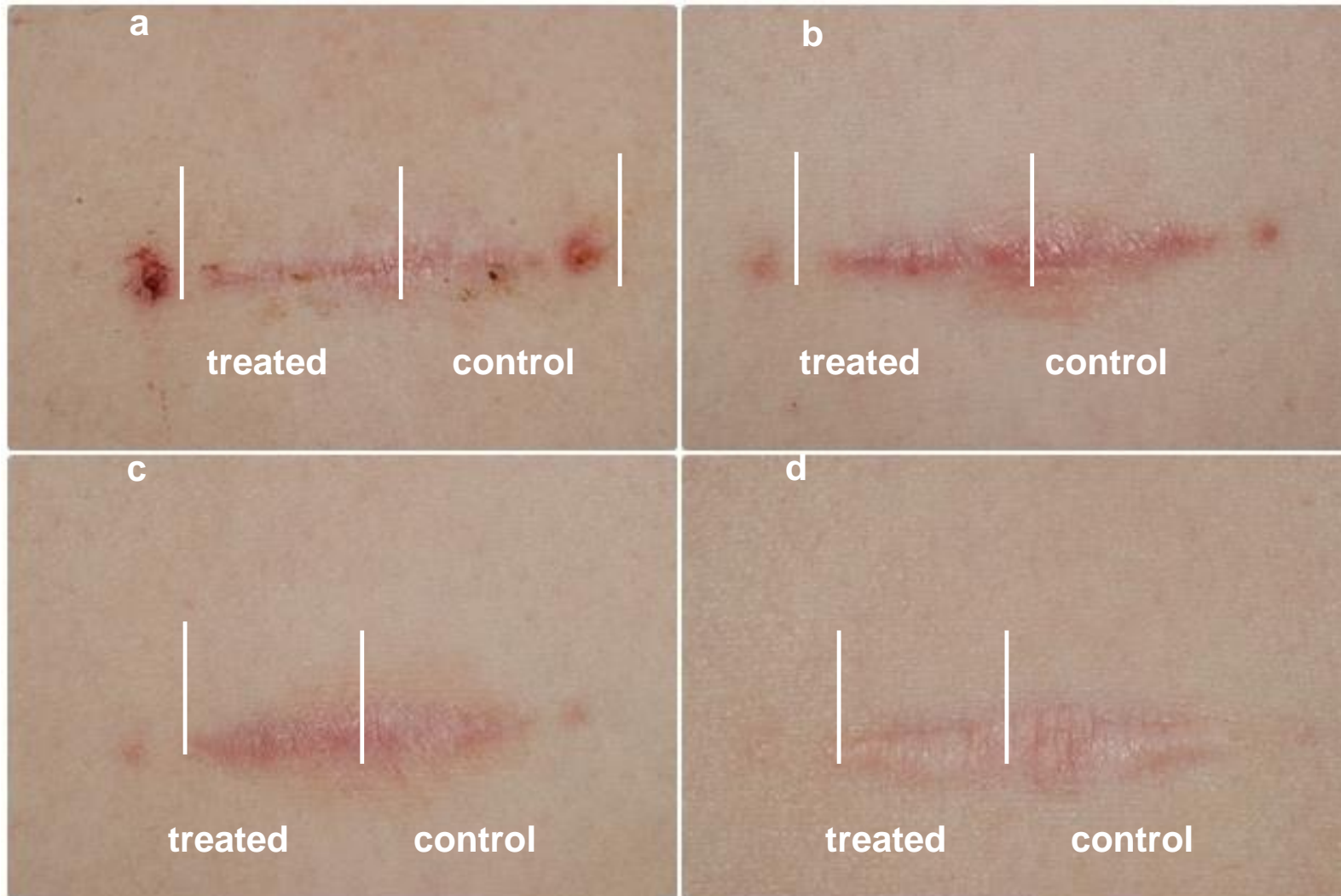
Multiplex: 7 mm spot size, **PDL/Nd:YAG** 12/50 J/cm², pulse duration 10/15 ms



PDL treatment of wart (2 sessions)



Multiplex PDL/Nd:YAG laser treatment of surgical scar

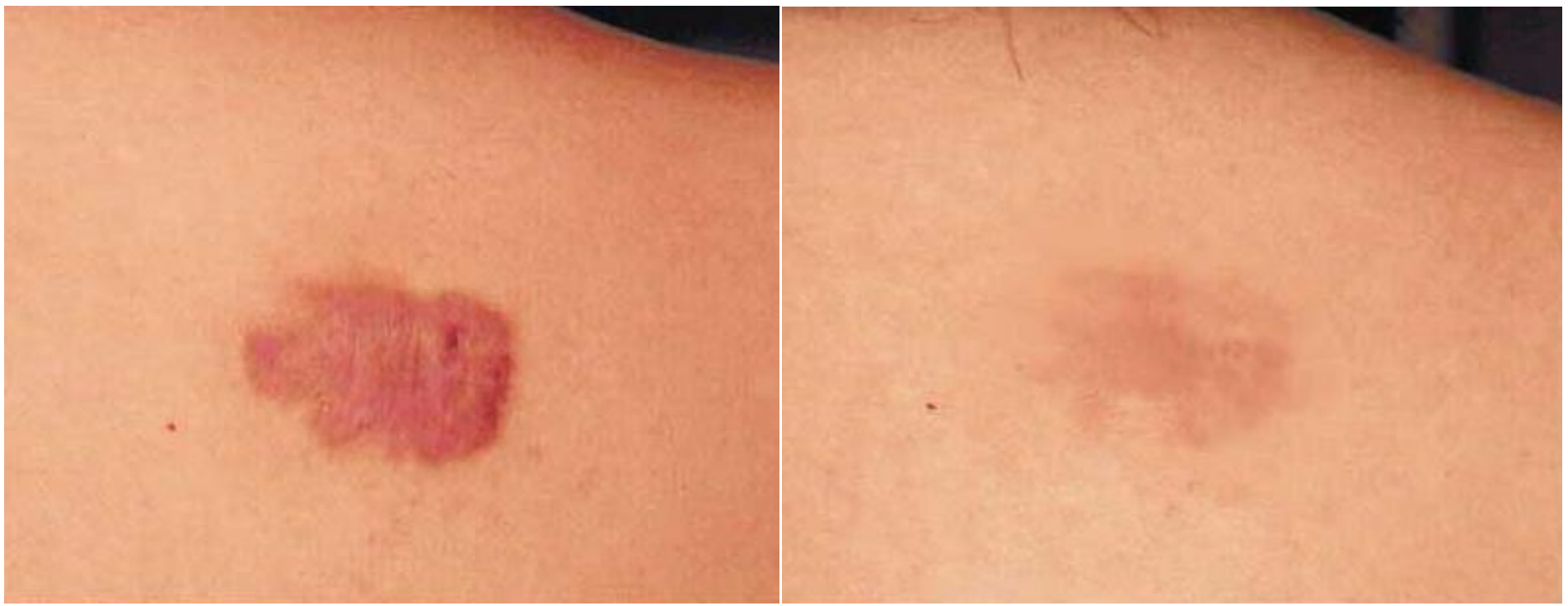


Vas K et al. Effects of the combined PDL/Nd:YAG laser on surgical scars: vascularity and collagen changes evaluated by in vivo confocal microscopy.

Biomed Res Int. 2014

a.) suture removal b.) one month after the first treatment c.) 2 months after the second treatment, d.) evaluation

Treatment of keloid with pulsed dye laser



Laser treatment of tattoo and pigmented lesions



Q-Switch (ns) vs. Long Pulse (ms) lasers

- ▶ **Melanosome**
 - ▶ approximately $1\ \mu\text{m}$ across
 - ▶ TRT 100's of ns
- ▶ **Q-switched Lasers**
 - ▶ Most likely rupture melanosomes, leading to cell damage
- ▶ **Long Pulse Light Sources**
 - ▶ Most likely damage cells with heat



Lasers for pigmented Lesions

Epidermal + Dermal

- | | |
|---------------------------|--------|
| 1. Q-switched Ruby | 694nm |
| 2. Q-Switched Alexandrite | 755nm |
| 3. Q-Switched Nd-YAG | 1064nm |
| 4. fractional Er:YAG, CO2 | |

Epidermal

- | | |
|-------------------|-------|
| 1. Pulsed Dye | 510nm |
| 2. FD Nd-YAG | 532nm |
| 3. LP Ruby | 694nm |
| 4. LP Alexandrite | 755nm |

-
- ▶ 5. IPL 400-720 nm

Benign pigmented lesions: epidermal lesions

- ▶ lentigines
- ▶ freckles
- ▶ café au lait macules
- ▶ naevus spilus
- ▶ seborrhoeic keratoses



Benign pigmented lesions: dermal lesions

- ▶ Naevus of Ota
- ▶ Naevus of Ito



Benign pigmented lesions: dermal-epidermal lesions

- ▶ melasma
- ▶ post-inflammatory hyperpigmentation
- ▶ Becker's naevus





▶ IPL treatment of ephelis (freckles)



Q-switched ruby laser treatment of PIH





Q-switched
ruby laser 3x



Melanocytic naevus regrowth: pseudomelanoma



Tattoo

▶ Decorative

▶ Cosmetic

▶ Medical

▶ Traumatic

▶ Professional or amateur

▶ Different colors

▶ Black 694 nm QS-ruby, 1064 nm QS-Nd:YAG

▶ Blue 694 nm QS-ruby

▶ Blue black

▶ Green 755 nm QS-alexandrite

▶ ▶ Red 585 nm PDL, 532 nm FD-Nd:YAG

Tattoo removal with Q-switched Ruby laser



➤ Photorejuvenation



Treatment of aging skin

The skin's natural aging process manifests as contour changes and rhytids secondary to the depletion of subcutaneous fat and the loss of dermal collagen.



A 69-year-old man who drove a delivery truck for 28 years shows damaged skin on the left side of his face.

NEW ENGLAND JOURNAL OF MEDICINE





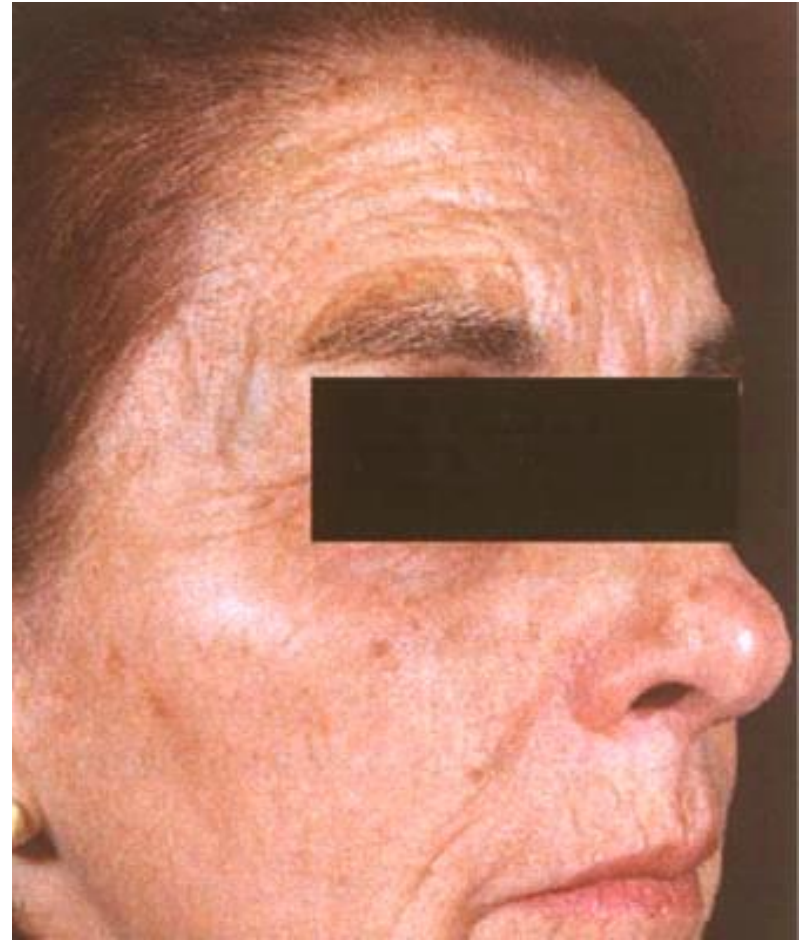


Resurfacing, Photorejuvenation

- ▶ Non-ablative photorejuvenation:
 - IPL
 - Nd:YAG
 - Diode laser 1450 nm
 - Er:glass 1540 nm
- Ablative laser resurfacing
 - ▶ 2940 nm Er:YAG
 - ▶ fractional Er:YAG
 - ▶ fractional 10600 nm CO₂



Photorejuvenation with IPL

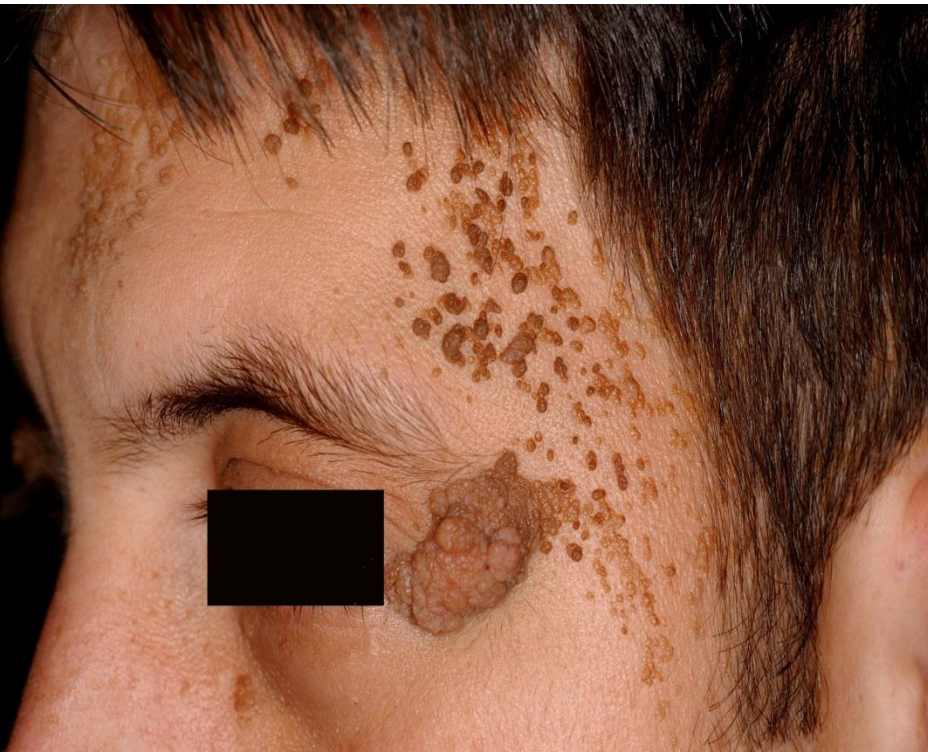


Ablative lasers



CO₂ laser treatment of epidermal verrucous naevus

before



after

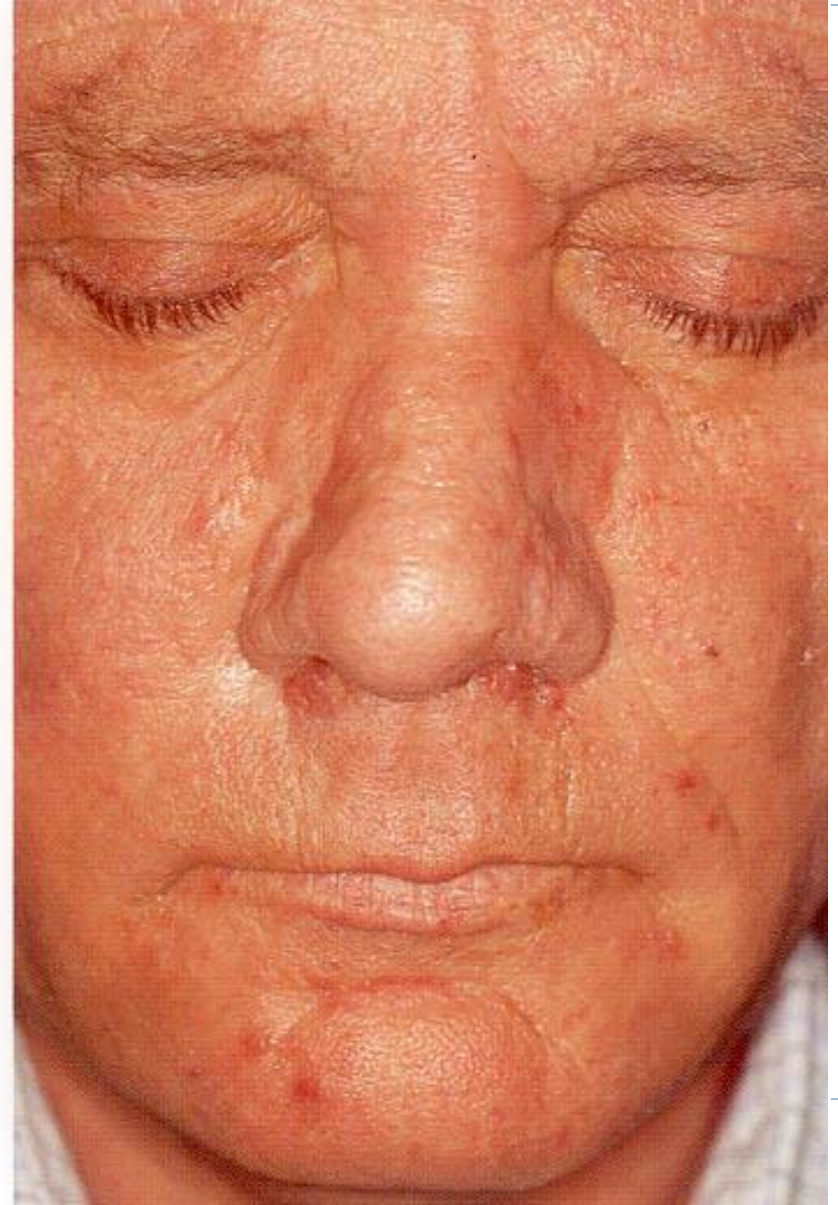




Soot particles: CO₂ laser 1x



Ablative laser treatment of rhynophyma with CO₂ laser



CO₂ laser treatment of xanthelasmas



CO₂ laser vaporization of verrucae planae

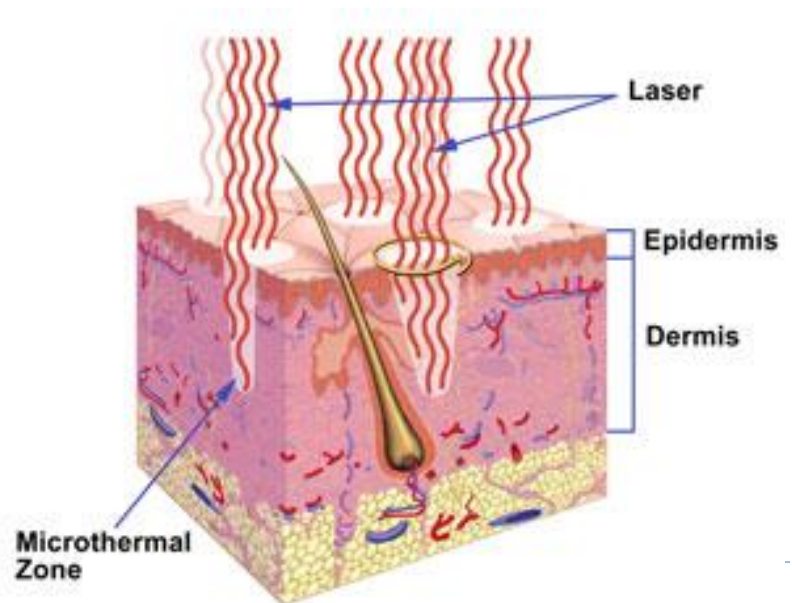
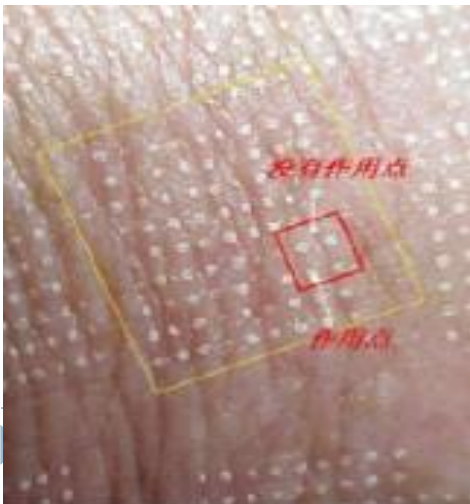


Fractional photothermolysis

- Fractional lasers

- 1550 nm Er fiber laser, 2940 nm Er:YAG, 10600 nm CO₂
- target: water
- tissue damage and remodelling in microscopic thermal zones (MTZ)
- pigmented lesions, rejuvenation

Manstein et al. Lasers Surg Med 2004



Other applications

- ▶ XeCl excimer laser (308 nm: UVB)
 - ▶ psoriasis
 - ▶ vitiligo
- ▶ multiplex laser in nail psoriasis
- ▶ onychomycosis laser treatment



Treatment of psoriasis with excimer laser (308 nm)



Treatment of vitiligo with excimer laser (308 nm)



Efficacy of Multiplex laser (PDL+Nd:YAG) in nail psoriasis

before treatment

after 5 treatments



Multiplex: 7 mm spot size, PDL/Nd:YAG 7/40 J/cm², pulse duration 10/15 ms



Laser therapy of onychomycosis: 1064 nm Nd:YAG

Clinical trials:

- methodology was not comprehensive
- reporting of outcomes was not unified
- small, uncontrolled and non-randomized trials
- meta-analysis is not possible

lack of mycological evaluation or only microscopic examination

the number of treatments, time intervals between them and follow-up periods varied



Complications of laser treatment

*Generally it is very safe with very low incidence of side effects, and can be used at any age.

- scarring(<1%)
- hyperpigmentation (10 - 15% , transient, resolves in 2-3 months)
- hypopigmentation (5%, transient, resolves within 2 months)
- demarcation lines
- delayed wound healing
- persistent erythema
- infections
- purpura



Complications of laser treatment: purpura

- ▶ Purpura and odema occurring after the treatment were transient.

„Although facial teleangiectasia do improve after a single purpura-free treatment with PDL, they improve more after purpura is induced.”

Murad Alam, Jeffrey Dover, Kenneth Arndt;

▶ Derm Surg, July 2003

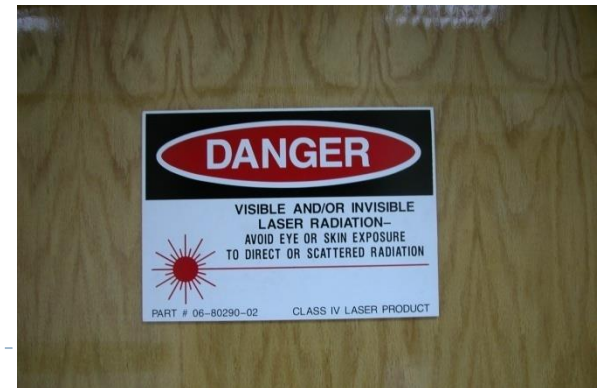
Pretreatment measures

- ▶ written consent
- ▶ pretreatment photograph
- ▶ anesthesia (usually topical)
- ▶ safety measures (precautions)



Safety measures (precautions)

- Protect eyes → eye glasses & shields.
- Laser off or standby when not in use.
- Plume or steam → smoke evacuator.
- Avoid reflecting objects.
- Labeling the theatre.



Post treatment measures

- ▶ sunscreen for 3 months after the end of last session.
- ▶ topical antibiotic ointment twice/day until disappearance of purpura / crust.
- ▶ bleaching agent whenever there is history of PIH.



