Lasers, Lights and Radiofrequency for Skin Rejuvenation

Dr. Walter WK King

Medical specialists in Hong Kong are well-trained and experienced in the use of lasers, lights and radiofrequency to induce aesthetic improvement and refinement of the skin of the face and body which has been altered or damaged by trauma, ageing, neoplasm, surgery, radiation and congenital conditions.

A laser is a high intensity, coherent light of a single wavelength. An intense pulsed light (IPL) is a high intensity, diffuse light of many wavelengths. When laser or IPL reaches the skin, specific targeted chromophore (e.g. melanin, oxyhaemoglobin, tattoo pigment, water) preferentially absorbs different wavelengths of light. Selective photothermolysis denotes the destruction of specific targets by microscopic heat upon the absorption of light of certain wavelengths by blood vessels, pigmented cells and melanised hair bulbs.

The efficacy in the selective destruction of specific targeted chromophore depends largely on the correct amount of energy delivered and the proximity of the pulse duration to the thermal relaxation time (TRT) of the targets such that the tissue exposure time to laser or light is short enough to confine the heat damage to the target without excessive heat diffusion to the adjacent normal tissue. TRT in term is based on the physical size of the target.

It was Einstein who first laid down the principles of stimulated emission of energy in 1917. MASER (Microwave amplification by the simulated emission of radiation) was first developed by Schalow and Townes in 1958 and the first ruby LASER (Light Amplification by the Stimulated Emission of Radiation) was developed by Maiman in 1960. Additional types of laser were rapidly developed in the ensuing 30 - 40 years.

All lasers consist of four basic components. i) The laser medium can be a gas (e.g. argon, excimer, carbon dioxide), a liquid (e.g. rhodamine dye as in pulsed dye laser) or a solid (e.g. ruby, Nd:YAG, alexandrite, erbium and dioxide lasers). ii) The optical cavity or resonator, iii) A delivery system and iv) The power supply or “pump” that generates excited atoms for amplification.

Tattoos and pigmentation have been effectively treated by Q-switched lasers (ruby, alexandrite and Nd:YAG). A Q-switch is a physical method to release extremely short (5-20 nanoseconds) pulses of laser light. Clinically, photo-acoustic waves are generated within the chromophobe targets causing cavitation of the pigment particles which are removed by phagocytosis by macrophages. On the other hand, long pulsed lasers coupled with higher fluences and larger spot size may be more effective in heating a larger volume of tissue at a deeper depth. (The larger the spot size, the less tissue scattering), a feature that is preferred in the laser or light treatment of unwanted body hair. In general, laser treatment of skin condition is safer than IPL treatments, contrary to popular belief since the learning curve for IPL treatment is long and steep.

Commonly used laser systems belong to one of eight categories:

I. Pigment Laser / Light Systems
II. Vascular Laser / Light Systems
III. Non-ablative Rejuvenation Laser / Light / Radiofrequency Systems
IV. Hair Reduction Laser / Light Systems
V. Ablative Resurfacing Laser Systems
VI. Microthermal Rejuvenation Laser Systems
VII. Surgical Laser Systems

I. Pigment Laser / Light Systems
Commonly used pigment reducing laser systems include QS NdYAG 1064, QS Alexandrite 755, QS-532, VP-532, long pulsed Alexandrite 755, IPL, IPL and radiofrequency (Aurora)(Fig.1). Clinical indications include the treatment of freckles, lentigines, naevus, melasma, naevus spilus, naevus of Ota, Becker naevus, eyebrow liner, eyelid liner, body tattoo, post inflammatory hyperpigmentation and pigmented scars.

Not all types of pigmentation will respond to laser / IPL treatments. In general, the response rate varies from 25% to 75% and the number of treatments varies from 3 to 15 at intervals of 4 - 6 weeks.

II. Vascular Laser / Light Systems
Commonly used laser / light systems for the treatment of vascular anomalies include pulsed dye 590/585, VP532, IPL, IPL and radiofrequency (Aurora), laser and radiofrequency (Polaris)(Fig.2), long pulsed Alexandrite 755. Clinical indications include port wine stain, rosacea, telangiectasia, poikiloderma civette, angioma, haemangioma, hypertrophic scars and leg veins. Port
wine stain may require 20 to 40 treatments and clearance may not be complete. Laser treatment of thick or deep haemangioma will require long pulsed Alexandrite or Nd:YAG lasers. Laser / IPL treatment of small leg veins gives treatment results equivalent to sclerotherapy both of which have associated side effects.

III. Non-ablative Rejuvenation Laser / Light / Radiofrequency Systems

Commonly used systems for skin tightening, firming and wrinkle reduction include IPL, Medilux, long pulsed Alexandrite, Polaris and Thermage. Except for Thermage (Fig.3) which uses radiofrequency alone to heat up the deep dermis (with simultaneous cryogen spray to protect the epidermis) in order to induce collagen to contract and tighten, the other laser systems deliver near-infrared (1064nm) or mid-infrared lasers (e.g. 1450 nm) which tends to target water as the chromophobe and heats up subsurface dermal tissues without wounding the epidermis. Most of these laser systems use some form of epidermal cooling systems. In wrinkle treatment, most sun damaged tissue resides from 100 - 600 um below the surface and the combined use of cooling system and radiofrequency / laser system are designed to heat up this substrate level of the skin. Thermage uses special treatment heads with variable sizes and depth of penetration to enable treatment of face, neck, eyelids and abdomen.

Effective Cooling Systems include cold air, cold gel, ice (cool roller), contact with sapphire and cryogen spray. Excessive cooling can result in complications including prolonged erythema, hyperpigmentation and hypopigmentation.

IV. Hair Reduction Laser / Light Systems

Commonly used hair reduction systems includes Gentlelase, IPL and Aurora, Medilux and Lightshear. Laser hair removal requires multiple (usually 6 to 10 treatment sessions) for long duration hair reduction and permanent hair removal may not be achievable in all patients. However, hair reduction by laser or IPL is superior to other methods of hair reduction (e.g. electrolysis) and the small risks are acceptable (dyschromia, scarring, hirsutism etc.) Laser / light removal systems include IPL, Aurora (IPL and radiofrequency), Gentlelase (long pulsed Alexandrite 755 nm) and Lightshear Dioxide laser system.

V. Ablative Resurfacing Laser Systems

Carbon dioxide lasers (Ultrapulse, Superpulse) and Erbium lasers delivered with 3mm spots are commonly used for the resurfacing of the skin to reduce wrinkles, laxity, surface irregularities or to treat skin lesions including warts, keratoses, naevus and sebaceous hyperplasia. Laser resurfacing procedures result in an open wound which is associated with increased risks of complications including herpes breakout, bacterial infection, dyschromia and scarring. Hence, large surface laser resurfacing is gradually replaced by non-ablative laser treatments.

VI. Microthermal Rejuvenation Laser Systems

Alternating microscopic low level heating with high level heating is the newest approach to dual level skin rejuvenation whereby collagen stimulation and remodelling is effected by near infrared laser operating at a wavelength of 1440nm and a pulse width of 3 msec. The Affirm Laser System uses lens array (Combined Apex Pulse Technology) to deliver apex high fluence zones surrounded by low level uniform heating zones. Apex high fluence remodels collagen and low level heating stimulates collagen.

With 5 treatment sessions at 4 - 6 weeks apart, periorbital wrinkles, upper lip lines, acne scarring, traumatic scarring; pigmentation and skin pores are all improved with minimal side effects. The Affirm microthermal rejuvenation approach represents the latest approach to painless skin rejuvenation with minimal downtime. Equivalent systems include Fraxel.

VII. Surgical Laser Systems

The Carbon Dioxide (CO₂) laser with a wavelength of 10,600nm is absorbed by water in the tissue. The absorbed heat (over 1,000 °C) causes tissue coagulation.
evaporation and sterilisation. Tissue penetration is limited to less than 1mm, therefore, collateral unwanted tissue destruction is minimal. Erbium laser (Er:YAG) at a wavelength of 2940nm is also absorbed by tissue water and can be delivered with shallower tissue penetration than the CO₂ laser. The Er:YAG laser ablates skin tissue from 5 to 30nm deep at fluences of 5 to 15J/m². Er:YAG also has less collateral tissue damage (between 5 - 20nm), therefore, skin resurfacing with Er:YAG yields a shorter recovering time. However, the Er:YAG does not produce coagulation and tissue can be continuously evaporated to produce an undesirable cavity depression.

Currently, plastic and aesthetic surgeons uses carbon dioxide laser with spot size of 0.2mm for precise incision with a dry surgical field and less swelling and ecchymoses after surgery. Suitable surgical procedures include transconjunctival lower blepharoplasty, upper blepharoplasty, endoscopic forehead lift and lip reduction surgery as well as a variety of oral surgery for excision of oral lesions.

Either carbon dioxide laser or erbium laser is also useful in shaving down benign raised skin lesions including moles, seborrheic keratoses, sebaceous hyperplasia, syringoma and atrophic scars.

Laser safety in Plastic & Anaesthetic Surgery. The following basic laser safety features should be incorporated into the design, layout and practice of an aesthetic laser unit:

(1) The laser room should have laser warning signs posted outside the room.
(2) The laser room should be locked from inside when laser is in use and an outside indicator light should be on.
(3) Manuals for laser systems should be easily accessible near the entrance of the laser room.
(4) The laser room should be well ventilated, cool and dehumidified.
(5) The laser room should have a minimum of reflective surfaces or glass panels. Windows should be draped or screened.
(6) A high flow vacuum suction system designed to reduce air pollution by viral and other particles should be on when laser is in use.
(7) Tap water and fire extinguisher should be easily available in case of fire and explosion.
(8) All staff inside the laser room should wear appropriate wavelength specific protective eye goggles and protective laser mask. Gowns and gloves are optional.
(9) Flammable sheets and blankets should be avoided.
(10) The patient’s eyes should be well covered with appropriate comfortable and protective eye goggles.

References