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Aesthetics

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Choosing Lasers for Vascular Concerns

Dr Asif Hussein and Dr Sajjad Rajpar share considerations for treating facial vascular concerns with lasers

With various options available on the market, selecting a laser for vascular lesions can be a challenge, especially to less experienced practitioners. This article discusses the core principles that determine choice of laser and considerations for successful results for facial vascular concerns.

Light-tissue interaction

A sound understanding of laser-tissue interactions is required as this underpins clinical laser dermatology. The target chromophore in the treatment of vascular lesions is haemoglobin.[1] Water can also be a secondary target. Haemoglobin comes in various oxygenation states: oxyhaemoglobin (Hb02), methaemoglobin and deoxyhaemoglobin.[2] The varying oxygenation states have subtle differences in absorption spectra as shown in **Figure 1**. This is an important consideration when refining choice of laser.

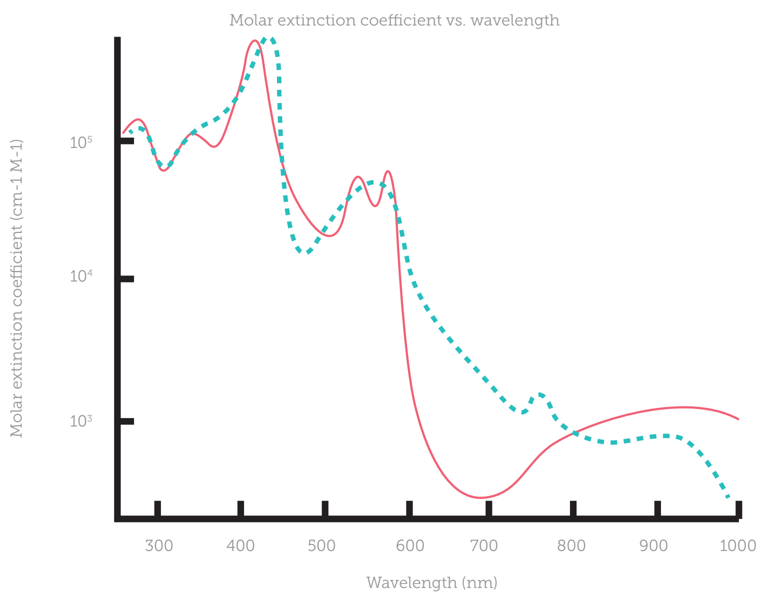

Figure 1: HbO2 (oxyhaemoglobin) and Hb (deoxyhaemoglobin) absorption spectra[2,4]

Selecting the correct wavelength

There are numerous peaks in the Hb/HbO2 absorption spectra as shown in **Figure 1**. Because melanin absorption is relatively high, in the 400-500 nm range, lasers in this wavelength are not specific enough for Hb/HB02 and would risk side effects such as permanent hypopigmentation.[3]

Wavelengths in the 500-600 nm (green to yellow light) range are the mainstay for vascular lesions as they are highly absorbed by Hb and relatively less well absorbed by melanin.[3] Lasers which are suitable for vascular indications are:[5]

- 532 nm KTP (potassium titanyl phosphate)
- 578 nm copper bromide laser
- 585-595 nm PDL (flashlamp pumped pulsed dye laser)

Melanin absorption is still significant for these wavelengths and is mitigated by cooling the epidermis and selecting an appropriate pulse duration to target vessels. Despite this, these lasers should be used with caution in darker skin types (defined as Fitzpatrick IV-VI), as the risk of dyspigmentation may outweigh treatment benefits.[6]

The 800-1100 nm (infrared light) range is also very useful for treatment of vascular lesions including:[3]

- 810 nm diode
- 940 nm diode
- 1064 nm long pulsed Nd:YAG

Due to lower melanin absorption, these wavelengths are safer on darker skin types.[7] Importantly, water absorption increases dramatically from 800-1100 nm, which can lead to bulk heating of tissue.[3] Cooling of non-target tissue is essential when using these lasers, otherwise indiscriminate thermal injury and scarring may result. Longer wavelength lasers penetrate deeper, with the Nd:YAG being the deepest penetrating laser in human tissue. It is important to be cautious of deeper-end arteries such as the alar artery when treating nasal thread veins, which may become inadvertently coagulated, leading to necrosis. Periorbital veins must be treated with caution as well and the use of internal metal eye shields is mandatory.[8]

Selecting the correct pulse duration

When selecting laser parameters, a pulse duration that is close to the thermal relaxation time of the target should be selected.[9] This ensures energy is confined

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Blood vessel diameter (telangiectasia 0-1mm)	TRT of whole structure
100 micrometres	10 milliseconds
400 micrometers	80 milliseconds
800 micrometers	300 milliseconds

Figure 2: Thermal relaxation times of blood vessels <1mm in diameter[10]

Dermal Structures	TRT of whole structure
Melanosome 0.5 micrometers	25 nanoseconds
Melanocyte 10 micrometers	1 microsecond
Hair follicle 200 micrometers	40 milliseconds

Figure 3: Competing structures in the skin and their thermal relaxation times[10]

to the target. Targets within the skin and their relevant thermal relaxation times are listed in **Figure 2** and **3**. Larger vessels have greater thermal relaxation times than smaller vessels and therefore require delivery of energy over a longer period of time. Telangiectasia (blood vessels <1mm in diameter) require pulse durations in the region of 1-60 milliseconds.[3,10]

Selecting the correct spot size

Larger spot sizes permit deeper penetration of laser energy. Deeper vessels therefore require larger spot sizes. Facial telangiectasia are usually superficial within the papillary or upper reticular dermis; comparably, leg telangiectasia are usually deeper, 1mm or more below the skin surface.[3]

With a 1064 nm, a small spot size of 3mm is adequate for facial telangiectasia, but inadequate for deeper leg telangiectasia. A spot size of >6mm would be much more suitable for leg telangiectasia over 3mm in diameter.[11] A spot size of 4-6mm on the face, however, would be extremely dangerous as the additional penetration from the larger spot size could lead to bulk thermal heating and coagulate superficial end arteries, such as the alar artery. As a general principle, treatment on the face should be confined to small spot sizes and to the smallest fluence sufficient to heat a blood vessel.[3] Larger spot sizes are required for leg veins where a greater depth of penetration is required – larger spot sizes ensure a greater chance of pan-vessel heating. However, there is greater bulk heating and risk of damage to collateral tissues.[12]

Tips for treating facial concerns

Redness, rosacea and telangiectasia are common vascular facial concerns that can be effectively treated using lasers. Facial telangiectasia are upper dermal vessels measuring less than 1mm in diameter.[2] They can occur from: intrinsic ageing of the skin, photodamage, rosacea, poikiloderma of Civatte, Osler-Weber-Rendu (hereditary haemorrhagic telangiectasia), CREST syndrome (spider angiomas), generalised essential telangiectasia, following chronic topical steroid usage, following radiotherapy or around a surgical scar in fair skin types.[2]

The principal chromophore for facial telangiectasias is HbO2, and the 532 nm and long pulse PDL (585-595 nm) are suitable laser choices for facial telangiectasias under 1mm in diameter as both wavelengths approximate to the Hb02 absorption peaks.[2,3]

When treating a smaller blood vessel, shorter pulse durations are required as smaller blood vessels will have smaller thermal relaxation times. Short pulse durations may lead to vessel wall rupture and purpura. Purpura is an annoyance for patients as the bruising can last for several days, leading to undesirable downtime, which must be discussed during consent.[3]

Historically, the PDL has been considered the gold-standard for treating vascular lesions.[2] Compared to the original 532 nm which used KTP, the PDL had a large enough spot size with adequate power to have utility for the greatest indications. Historically, KTP-based 532 nm lasers had spot sizes of 2mm or less, lacked power, and relied on shot stacking to create a quasi-continuous laser to achieve a therapeutic result with increased risk of epidermal injury.[13] These features effectively excluded KTP lasers for diffuse redness, rosacea, and larger port wine stains, despite the fact that the absorption by Hb02 of 532 nm is five times greater than it is for 595 nm.[3] Melanin absorption is, however, only 10% greater for 532 nm compared to 595 nm; consequently the 'vascular to melanin damage' ratio is much greater for 532 nm than for 595 nm.[3] Since 2007, KTP lasers have offered larger spot sizes with adequate power. This allows for effective treatment of diffuse redness and larger port wine stains – yet their generalised use has been less widespread. More recently, 532 nm lasers using lithium triborate (LBO) crystals instead of KTP have offered stability, larger spot sizes and enhanced power.[3] **Figure 4** shows a Type 1 rosacea patient treated with a single session of large spot 532 nm LBO laser. In our experience, multiple treatments with combined Nd:YAG and PDL would be required to get this level of clearance.

A single-blind, split face, controlled comparison study involving 15 subjects with facial redness and telangiectasias indicated

Figure 4: Patient presenting with type 1 rosacea and two weeks after one session of treatment with 532 nm, 8mm spot. Photos courtesy of Dr Asif Hussein.

Figure 5: Treatment of larger nasal telangiectasia with Cutera Excel V+ 3mm spot 1064 nm. Photos courtesy of Dr Asif Hussein.

Optical coherence tomography

Optical coherence tomography (OCT) is a non-invasive way of looking at small structures under the skin. OCT can determine the depth and diameter of cutaneous vessels.[16] While not a standard procedure, increasing utility for OCT in inflammatory and malignant skin conditions is being reported.[17] We find that OCT provides valuable information selecting the correct parameters, especially for complex lesions. A vascular laser workstation can safely and effectively treat the majority of cutaneous vascular lesions in practice.

Figure 6: Optimisation of laser parameters with Vivosight optical coherence tomography. Photo courtesy of Dr Asif Hussein.

> Longer wavelength lasers penetrate deeper, with the Nd:YAG being the deepest penetrating laser in human tissue

that large spot 532 nm KTP was superior to 595 nm PDL in all treated subjects.[14] There was more transient swelling and erythema with the KTP. This has always proven to be true in our experience. In line with this paper, we find that the large spot laser is generally more effective than the large spot 595 nm PDL in treatment of rosacea, facial redness and red telangiectasia. Greater swelling and oedema arises with KTP and this is probably due to increased 532 nm wavelength absorption by melanin and haemoglobin, resulting in more diffuse epidermal and superficial dermal inflammation. However, even though 532 nm is more highly absorbed by epidermal melanin, the relative ratio between haemoglobin to melanin absorption is much greater with 532 nm compared to 595 nm.[3]

Larger facial telangiectasias

The penetration of laser energy becomes insufficient to heat the full cross section of greater than 0.6mm in diameter. The KTP/PDL may thermally damage the ceiling of larger vessels and cause transient vasoconstriction, giving a false impression of clearance. The Nd:YAG is the preferred choice by most for vessels >1mm in diameter.[3]

We use the long pulsed Nd:YAG for these indications, as this provides a deeper penetration. Facial telangiectasias are treated with a 2-3mm spot size to limit collateral damage to deeper facial arteries that may occur with larger spot sizes. Intra-ocular metal eye shields must be used when treating vessels near the orbital margin. Treatment within the bony orbit should be carried out with extreme caution. Treatment with the long pulsed Nd:YAG for facial vasculature of >0.5mm in diameter is well established.[15]

Bulk heating is mitigated by cooling the skin well and never overlapping shots. A spot-welding technique with spatial gaps between shots is used. **Figure 5** shows a gentleman who has relatively large >0.5mm nasal telangiectasia. These were completely cleared with two sessions of long pulsed Nd:YAG treatment four weeks apart.

Summary

We offer both 532 nm and 595 nm wavelengths in practice. However, for the everyday common indications of rosacea, facial redness and telangiectasia, we find a 532 nm/1064 nm (NdYAG) vascular workstation offers superior outcomes and greater stability, with lower running costs compared to the 595 nm/1064 nm (PDL/Nd:YAG).

Dr Asif Hussein specialises in cosmetic dermatology and cutaneous laser surgery. He is clinical director of DrHConsult and medical director at sk:n London Westminster. Dr Hussein partners and operates with Dr Sajjad Rajpar at Belgravia Dermatology London and his specialist interests include fully ablative laser surgery and cutaneous vascular laser.
Qual: MBBS DHMSA DipDerm

Dr Sajjad Rajpar is a consultant dermatologist at Belgravia Dermatology, specialising in laser and surgical dermatology. Dr Rajpar qualified from Birmingham University in 2000 and completed dermatology training in the West Midlands, which led to a specialist fellowship training in Mohs surgery and cosmetic dermatology in New Zealand.
Qual: MBChB (Hons) FRCP

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