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Laser treatment with 532 nm wavelength offers numerous advantages

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The next several columns will examine the wavelengths commonly used in dermatology. Understanding the properties of the wavelength and how it is produced helps give background knowledge leading to more successful clinical outcomes with these devices. This is a review of publications, and some of the treatments mentioned are considered off-label for some of the devices.

A 532 nanometer (nm) wavelength is obtained by passing a 1,064 nm neodymium YAG (Nd:YAG) source through a potassium titanyl phosphate (KTP) crystal, resulting in frequency doubling of the light and emission of green light. These devices are commonly referred to as either the KTP laser or the frequency-doubled Nd:YAG.

A lithium borate crystal can also be used in the laser resonator to frequency-double the 1,064 nm, producing the 532 nm green light. The pumping systems for this laser vary and include arc lamps, flash lamps and diodes. The KTP has been used extensively in the treatment of vascular lesions and cutaneous pigmentation, but it also has been used outside the field of dermatology for vaporization of the prostate, laser pointers and with photosensitizers for bleaching of the teeth.

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Selective photothermolysis

Selective photothermolysis, as described by Anderson and Parrish in 1981, occurs due to the properties of the wavelength of light and the properties of the tissue chromophore. At 532 nm, high absorption by both hemoglobin and melanin occurs. The absorption of light by hemoglobin is higher at 532 nm than at the traditional 585 nm pulsed-light wavelength. However, the absorption by melanin is also greater at 532 nm than at 585 nm. Due to these innate factors of the wavelength, vascular lesions are easily targeted. Care must be taken, however, to use adequate cooling to protect the pigment-containing epidermis.

Absorption by both melanin and hemoglobin can be useful for treating lesions with both components, such as poikiloderma of Civatte or photoaging. Having a high absorption coefficient for melanin is also an advantage when treating pigmented lesions such as solar lentigines. The 532 nm wavelength has such a high affinity for pigment that treatment of even very light lesions is possible. Treatment of darker skin types with any short wavelength can be more complicated, however, and appropriate pulse widths and epidermal cooling are crucial.

In 1986, Apfelberg et al described for the first time the use of a 532 nm wavelength light for skin lesions including port wine stains, hemangiomas and tattoos (Apfelberg DB, Bailin P, Rosenberg H. *Lasers Surg Med*. 1986;6(1):38-42). As demonstrated by Apfelberg, the 532 nm wavelength is a versatile wavelength, in that adjustments in the manner of delivery result in the ability to treat a diverse array of cutaneous lesions.

Pulse width and cooling

The effects of the KTP laser on the skin can be modified by altering the pulse width and the cooling on the device. Effective cooling of the epidermis will result in a relative sparing of the pigment, with better

targeting of the hemoglobin-containing structures. Used with minimal or no cooling of the epidermis results in treatment of the pigmented lesions in the epidermis, with little to no effect on the underlying vessels.

Pulse width plays a crucial role in any laser device. The ideal pulse width of the device should be equal to or less than the thermal relaxation time (Trt) of the target. This will result in the least amount of heat transfer to the surrounding normal tissues and the most selectivity for the desired target. As the Trt of melanin is very quick, short pulsed widths are employed for treatment of pigment.

The KTP is commonly used in the Q-switched mode (ns) for treatment of pigment including red tattoos. Longer pulse widths have a deeper relative penetration and are able to treat larger targets, such as vessels on the face. By varying these parameters, one device can be used to treat several different types of lesions.

Shorter wavelengths have less penetration through the skin due to trapping by hemoglobin and melanin and also due to scatter. Longer wavelengths are able to penetrate deeper and are more suitable for deeper/thicker lesions.

At 532 nm, light cannot penetrate as deeply as some of the other wavelengths that are less well absorbed by pigment or hemoglobin. Green light essentially gets trapped by pigment or hemoglobin in the more superficial layers of the skin. That, combined with the scattering of shorter wavelengths, results in a superficial effective penetration of light.

The 532 nm wavelength is able to reach the superficial dermis for treatment of dermal vessels, but it is not suitable for treatment of deeper vessels such as spider veins of the lower extremities.

Pigmented lesions

Solar lentigines have a superficial placement and can be treated with most wavelengths that are well absorbed by melanin, including the 532 nm devices. Other methods of removing pigmented lesions using lasers poorly absorbed by melanin are also possible via resurfacing.

Lighter pigmented lesions can be challenging to treat with laser. The 532 nm wavelength is very well absorbed by melanin, making it a great choice for lighter lesions. Bassichis et al reported that most patients are satisfied after three KTP treatments, spaced two to four weeks apart, and that results continue to improve over a three-month period of time.

They used a KTP laser to treat solar lentigines in skin types I to IV (and occasionally V) with a 2 mm handpiece, low energy settings and one pass (Bassichis BA, Swamy R, Dayan SH. *Facial Plast Surg*. 2004;20(1):77-83). Cooling is not required in the treatment of pigmented lesions with a 532 nm laser except in darker skin types. In fact, overcooling of the epidermis will result in sparing of the epidermis and an ineffective treatment of the pigment.

Other indications

Due to its high affinity for hemoglobin, the KTP is an excellent choice for treatment of superficial vessels. There are publications indicating clinical success for treatment of rosacea with the KTP laser (Miller A. *J Drugs Dermatol*. 2005;4(6):760-766; Clark C, Cameron H, Moseley H, et al. *Lasers Med Sci*. 2004;19(1):1-5). The general consensus is that longer pulse widths may be superior to shorter pulse widths for diffuse redness.

Using longer pulse widths (>15 ms) also reduces the incidence of vessel rupture, resulting in less intradermal hemorrhage and a lower incidence of purpura. Shorter pulse widths are employed in treatment of smaller discrete vessels with a lengthening of the pulse width as the vessel diameter increases. The KTP has also been used successfully for treatment of endonasal vessels.

Acne

Although not considered a first-line treatment for acne, there are a few published reports of using KTP for acne.

A randomized, split-face trial (n = 26 patients) evaluated the efficacy of four treatments within two weeks with the KTP laser and continuous contact cooling versus sham treatment with contact cooling alone. Total acne lesion scores improved 35 percent (one week, $P < 0.01$) and 21 percent (four weeks, $P = 0.09$) after laser treatment versus no improvement after sham treatment (Baugh WP, Kucaba WD. *Dermatol Surg*. 2005;31(10):1290-1296).

In 2010, an open-label, split-face study compared aminolevulinic acid (ALA) (30 minutes) plus KTP laser to KTP laser alone for the treatment of moderate facial acne. Eight patients, skin types I to III, completed three treatments, spaced three to four weeks. A spot size of 10 mm, fluence of 7 J/cm^2 , pulse duration of 30 seconds and two passes were used.

After the third treatment session, evaluated at week 12, the acne score improved by 39 percent with ALA-laser treatment, and by 34 percent with laser treatment alone. Statistical differences were not detected with or without ALA treatment (Sadick N. *J Drugs Dermatol*. 2010;9(3):229-233).

Poikiloderma of Civatte

There is just one case report that used a KTP laser for poikiloderma of Civatte: four treatments, 13 mm diameter delivery device, 1 ms pulse duration and repetition rate of 10 pulses per second at energy fluences of 10-15 J/cm^2 . The authors referred excellent results but reported hyperpigmentation at some settings (Batta K, Hindson C, Cotterill JA, et al. *Br J Dermatol*. 1999;140(6):1191-1192).

The properties of the wavelength itself would make 532 nm an excellent option for this condition, but more studies are necessary.

Tattoos

Used in the Q-switched mode, the KTP laser can be used to remove red-colored tattoo ink. The extremely short pulse width (ns) allows for vaporization of the ink. Even though 532 nm is well absorbed by other colors, the Nd:YAG (1,064 nm) and the alexandrite (755 nm) provide better penetration and a superior clinical result for dark-colored (blue/black) tattoos.

The 532 nm wavelength is very versatile. Its absorption by both melanin and hemoglobin give it both advantages and disadvantages. In general, KTP lasers are very effective for superficial vessels and pigmentation but more difficult to use on dark skin.

Using the 532 nm in a short pulse width setting with little or no cooling allows for treatment of epidermal pigmentation. Lengthening the pulse width and adding cooling targets dermal structures such as superficial vascular structures.

Diseases that combine both pigmentation and vascular lesions are also well treated using the 532 nm devices. Deeper vessels do not respond well to the shorter-wavelength vascular lasers and generally require a longer-wavelength device, such as the 1,064 nm Nd:YAG.

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