Laser Surgery for Dermatologic Conditions in Pediatric Patients

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KEYWORDS

• Laser • Pediatric dermatology • Vascular • Pigmented lesion • Hidradenitis suppurativa • Warts, Nevus of Ota

KEY POINTS

- Laser therapy is an effective treatment that can be used in a wide range of cutaneous conditions in pediatric dermatology.
- Real time tissue response to laser treatment can inform therapeutic effect, potential complications of the therapy, and whether parameter adjustments are necessary.
- The various make and models of lasers have different therapeutic settings that are not always generalizable across lasers of a specific wavelength.
- Safety precautions and type anesthesia are important considerations in pediatric patients.

INTRODUCTION

Laser is an acronym for light amplification by the stimulated emission of radiation. They have been widely used to treat various cutaneous disorders in pediatric dermatology. They are a valuable tool for pediatric dermatologists to have in their therapeutic toolbox as they can offer significant benefits with minimal morbidity. Lasers generate light of a specific wavelength by using energy in the form of an oscillating current to excite molecules within a certain media; solids (crystals), liquids (dyes), or gas (argon or CO2). As the current passes through one of these mediums the light that is discharged is coherent, meaning that the photos are precisely parallel (collimated) and aligned in both space and time. A coherent light can travel longer distances without attenuation. The wavelength of the laser is an important component of selective photothermolysis.[1] The longer the wavelength of the laser, generally the deeper the penetration of the energy. For wavelengths higher than 1064 nm the depth of penetration of the laser decreases as increased energy is dissipated into the surrounding tissue.

Lasers work through the concept of selective photothermolysis, allowing them to deliver energy very precisely based on the specific characteristics of the targeted tissue. The targeted chromophore and the size and depth of the lesion are the important characteristics of the tissue that help direct the appropriate laser wavelength choice to produce the most effective outcome. The 3 main chromophores within the tissue that absorb the energy of the laser are hemoglobin, melanin, and water. Chromophores have varying absorption spectrums and at select wavelengths, they have peaks in their absorption of the energy delivered by the laser. This allows for a more efficient transfer of energy to the targeted tissue, which minimizes tissue damage to the surrounding skin.

Selection of a laser

The selection of the specific wavelength of laser and parameters used is largely based on the following concepts:

1. Chromophore (considering the absorption spectrum and peaks of absorption)
2. Depth of the lesion
3. Size of the lesion

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4. Individual characteristics of the patient (skin type, age, location being treated, and so forth)

Laser Types

There are 3 main categories of laser types; millisecond lasers, quality-switched (QS) laser, and ablative/nonablative lasers (**Table 1**). The concepts surrounding the millisecond and QS lasers have to do with pulse duration. The pulse duration, also known as the pulse width, is the time in which a targeted tissue is exposed to laser energy. A key factor in determining optimal pulse duration is thermal relaxation time. Thermal relaxation time refers to the time that it takes a photon to heat and then cool. In general, the larger the diameter of the target (ie, vessel, melanosome, pigmented molecule) within the tissue is longer the pulse duration. Millisecond lasers tend to target vascular lesions with larger diameter targets than quality-switched (QS) lasers that target very small tattoo particles or pigment granules within melanosomes. The chromophore of millisecond lasers is oxyhemoglobin and QS lasers is melanin. The specific type of laser chosen not only has to do with the type of tissue being targeted, but also with the depth of the lesion. The longer the wavelength, the deeper the laser energy will penetrate. The third category of lasers is ablative and nonablative lasers that target water as their chromophore. Ablative means that the laser vaporizes or ablates the area treated to destroy or remove the tissue completely. Nonablative lasers on the other hand transfer energy to injure the tissue through melting or coagulating the tissue. Both of these modes activate tissue healing to improve the skin texture. The ablative and nonablative lasers can further be fractionated, meaning that instead of fully ablating an area, the tissue is broken up into adjacent zones of normal tissue and treated tissue in a checkerboard pattern. Fractionated lasers have quicker recovery times than fully ablative laser treatments due to the fact that normal tissue is sitting adjacent to the treated areas allowing remodeling of tissue to occur more rapidly.

Laser devices

It should be noted that lasers of a specific wavelength come in different models and brands and have different parameters for the treatment of similar conditions. Therefore, it is difficult to extrapolate published laser settings to all lasers within even a specific wavelength. Treatment protocols vary by device; therefore, understanding the laser-specific treatment's parameters for your device and expected versus dangerous tissue response endpoints, are an important guide therapy.

Laser safety

Eye safety is of the utmost importance for the patient and all individuals in the laser treatment room.[2] The surgeon should call out before the procedure the appropriate glasses to wear with the wavelength corresponding to the laser being used, color of glasses, and ensure all in the room have eye protection. Individuals in the laser room should also check glasses to ensure the wavelength of laser people used in appropriate for their glasses. Depending on the treatment site, the patient should be protected with either opaque eye pads (if lasering the face), metal corneal eye shields (if lasering around the eye), or if the treated area is not on the face and depending on the age/cooperation of the patient, it may be possible for them to wear laser goggles if proper fit and compliance are assured. Cotton or adhesive laser-safe eye pads, when treating very young children, are often held in place during the procedure by a member of the treatment team. When treating within the orbital rim, a metal corneal eye shield should be placed with anesthetic eye drops and nonflammable lubricant eye gel to avoid corneal abrasions.

Using a smoke evacuator and appropriate masks for all in the room is also important during procedures. Reports of viral plume present in the air after the laser treatment of warts, especially with the use of CO2 lasers.[3] Risk of infection with human papillomavirus was greatest with treating genital warts.[4] Surgical masks have been effective in decreasing the risk of HPV infection to surgeon and staff. There have also been reports documenting the release of hazardous and ultrafine particles after laser hair removal procedures into the air and having ill effects on health.[5,6] In addition, the smell of charring skin and hair can be uncomfortable to patients and staff in the treatment room. The use of smoke evacuators has been shown to be effective at clearing the release of these nanoparticles when used during laser procedures of hair-bearing areas. It is recommended that smoke evacuators be used for the safety of all surgeons and staff during laser hair removal procedures.[7]

Anesthesia considerations

There are a variety of anesthesia options that can be used with laser therapy. Pretreatment with topical amide anesthetics such as topical lidocaine or prilocaine, use of oral pain medications such as acetaminophen and nonsteroidal anti-inflammatories, or intra-nasal or oral anxiolytic medications are options depending on the clinical context and setting. Nonsteroidal anti-inflammatories should be avoided when treating

Table 1
Laser types

Millisecond Lasers	Quality-Switched Lasers	Ablative	Nonablative
Pulsed Dye Laser (595 nm)	Quality-Switched KTP/ Frequency-doubled Nd Yag (532 nm)	Carbon Dioxide (CO2) (10,600 nm)	Erbium: Glass (1540 nm)
Potassium Titanyl Phosphate (KTP)/ Long-pulsed frequency-doubled Nd Yag (532 nm)	Quality-Switched Ruby (694 nm)	Erbium-yttrium argon garnet (Er:YAG) (2,940 nm)	
Long-Pulsed Alexandrite Laser (755 nm)	Quality-Switched Alexandrite (755 nm)		
Long-Pulsed Diode Laser (800–810, 940, 980 nm)	Quality-Switched Long-pulsed Nd Yag (1064 nm)		
Long-Pulsed Nd Yag Laser (1064 nm)			

vascular lesions. Injectable anesthetics can also be used to perform nerve blocks to anesthetize areas before the use of ablative and nonablative lasers or deeper-penetrating lasers such as LP Nd Yag.

During laser treatment, gate control theory has been used by applying pressure directly to the skin or tapping the skin to activate pressure receptors and diminish pain response from laser treatment by having a decrease in pain sensation travel to the central nervous system. The gate control theory of pain describes how using nonpainful sensations to activate tactile and pressure skin receptors can naturally block the transmission of pain to the brain during the laser procedure.[8] In addition, skin cooling via cryogen spray, direct cooling tip within the laser, or forced cooling air have also been used to decrease intraoperative pain. As an adjuvant to anesthesia, distraction techniques can also be used to help mitigate pain and discomfort. During laser cases music, tactile and sensory tools such as the use of stress balls or fidget objects, and use of screens when patients able to safely use laser glasses can be used.

General anesthesia in the operating room under the guidance of trained anesthesiologists can also be used when needed. Currently limited studies and FDA warning have discussed the potential neurocognitive effects associated with anesthesia in young children, especially with repeated anesthesia events in patients under the age of 3 years.[9] When selecting the correct anesthesia mode for a patient, shared decision-making should be used, and a discussion of potential risks and benefits should be had with patients and families.

Monitoring tissue response and evaluation of clinical endpoints

The clinical endpoint is observed intraoperatively and allows the laser surgeon to gauge the therapeutic effect of the laser treatment. The surgeon is able to assess whether laser settings are correct to achieve the desired endpoint or if any fine-tuning of laser parameters are needed. Laser settings such as energy/fluence, spot size, and pulse duration can be changed based on observed clinical endpoints. Some tissue responses are seen immediately, while others may take a few minutes to become visible. The desired clinical endpoints and those that can be signs of tissue damage and should be avoided vary by the type of laser being used and the chromophore being targeted. These endpoints are outlined in **Table 2**.

Procedural considerations

- Preprocedure:
  - Strict sun protection starting at least 6 to 8 weeks before the procedure to reduce competing epidermal melanin content
  - Assess infection risk (highest with HSV infections and with ablative laser resurfacing, the risk still low at approximately 5% of procedures, nonablative procedures 0.6% risk) and start antiviral for Herpes labialis prophylaxis treatment 1 day before laser procedure in those at high risk.

Table 2
Tissue response and clinical endpoints

Chromophore (Target)	Lasers Used	Desired Clinical Endpoint	Signs of Tissue Injury
Hemoglobin	PDL, KTP, Alexandrite,	Purpura, vessel darkening, vessel disappearance	Gray or white coloration of the tissue; blistering or positive Nikolsky sign (late)
Hemoglobin	LP Nd Yag	Erythema (may take a few minutes to develop), vessel darkening, or vessel contraction	Gray or white coloration of the tissue; blistering
Hemoglobin (warts)	PDL, LP Nd Yag	Intense purpura	Blister, scar
Melanin (laser hair removal)	LP Ruby, LP Alexandrite, LP Nd Yag	Perifollicular erythema and edema, erythema (delayed response, may take up to 5 min to be visible)	Dyspigmentation (late)
Melanin and dermal pigmentation	Q-switched Ruby, Q-switched Alexandrite, Q-switched Nd Yag	Frosting, superficial whitening, and auditory snap or crack	Dyspigmentation (late)

- Postprocedure:
  - Cold compresses and ice used for 24 to 48 hours after the laser procedure
  - Petrolatum-based ointment is recommended immediately postop and until the area is completely healed.
  - Protect site treated from friction and trauma
  - Typically patients can return to school and daily activities on the same day or within 2 to 3 days of laser treatment depending on laser, site, and surface area treated
  - Compression garments can be helpful to reduce laser-induced postoperative edema (ie, treatment of venous malformations (VM))
  - Sun protection and avoidance of direct sun exposure
  - Use of adjuvant treatments such as topical rapamycin should start immediately after laser treatment
  - Oral antihistamines and topical steroid ointment may be recommended for patients who develop immediate urticarial reactions to laser treatment

DISEASE-SPECIFIC LASER TREATMENT

Laser treatment of vascular lesions

Lasers are widely used and often considered first-line treatment of many vascular lesions. The chromophore for vascular lesions is oxyhemoglobin, which has the greatest absorption peaks at 418, 542, 577 nm. The energy from the laser is absorbed by oxyhemoglobin and this heat energy is then transferred to the wall of the vessel, causing the destruction of the vessel by coagulation and closure or leakage of the vessel. For many vascular lesions, the PDL laser (585–600 nm; 595 nm most common) is most often used. The PDL penetrates to a maximum depth of 1.2 mm. Deoxyhemoglobin is another chromophore within vascular lesions that can be targeted. This is the chromophore of choice within VM and refractory and hypertrophic port-wine birthmarks (PWB), with its absorption peak near 750 nm and 930 nm. For deoxyhemoglobin, the Alexandrite laser (755 nm) and Long-pulsed Nd Yag laser (1064 nm) have been used as their wavelengths more closely align with the absorption peaks of deoxyhemoglobin.

Port-wine birthmarks

Port-wine birthmarks (PWB) are largely congenital vascular malformations that are present at birth and comprised of ectatic capillaries and postcapillary venules within the superficial vascular plexus. PWB were previously referred to as "port wine stains," but the term stain holds a negative connotation and therefore the preferred term is PWB.[10] PWB are persistent and grow proportionally with the patient. PWB can become darker, hypertrophic, nodular, develop vascular pyogenic

granuloma-like blebs, and can have associated soft-tissue overgrowth due to progressive vascular ectasia and enlargement of the diameter of vessels.[11] The size of the vessels can vary significantly within PWB from 7 to 300 μm, with larger vessel size in adults and in darker PWB. Laser treatment of PWB is aimed to decrease these effects, as well as reduce psycho-social burden on patients and families.

Pulsed dye laser has been effective in treating PWB in patients of all skin types, but the individual response is variable. Therapeutic effect is based on many factors such as size and depth of lesion, location, and individual characteristics such as skin pigmentation and age. Approximately 20% of patients experience complete clearance and 80% have a decrease in color and thickness of their PWB.[12] In darker-skinned individuals with dynamic cooling, clearance rates and effectiveness of PDL was also favorable.[13,14] Predictors of more favorable treatment outcomes include small size (<20 cm^2), location over bony areas such as the central forehead whereby the depth of the skin is thinner, and initiation of early treatment (<6 months of age).[15] Early initiation of therapy has shown greater rates of clearance with infants who initiated therapy before 6 months of age were noted to have rates of clearance close to 90% after 1 year of treatment.[16] Early treatment is thought to be effective for a variety of reasons. In younger patients, the skin is thinner, which allows for better penetration of the laser to ectatic capillaries at varying depths. There is less melanin present in younger patients which not only causes less side effects from the laser, but there is also less uptake of energy in the surrounding tissues due to less competition for the laser target. Hemoglobin F is present in infants which allows for an additional target for laser therapy. Finally, the diameter or the dilation of lesional vessels is decreased in younger individuals making them more amenable to laser treatment.

Treatment intervals vary and have been documented from 2 to 6 weeks. Recent meta-analysis and systemic review of the literature demonstrated that time intervals between PDL treatments were not associated with PWB outcomes, but younger age at intervention, light Fitzpatrick skin type, and facial location were associated with increased improvement rates.[17] Multiple treatments are often required to achieve clearance or a plateau in response. Often 10 or more treatments have proven to be beneficial. Typically, the desired tissue endpoint with pulsed dye laser is immediate purpura; however, purpura may be delayed if larger spot sizes are used. If laser fluence is too high there can be a gray to white color or blistering of the skin. This endpoint is not always immediately evident and indicates epidermal injury that may not be reversible and may lead to scarring. Therefore, careful monitoring of tissue response—purpura, edema, blistering—is incredibly important intraoperatively in areas immediately being lasered as well as those that have just been lasered.

Bruising (purpura) and mild swelling of the treated areas are expected outcomes after laser and may last 1 to 2 weeks after treatment. Hyper or hypopigmentation of the tissue may also occur and is often transient. Darker-skinned individuals are more at risk for skin dyspigmentation after laser treatment which may last longer. Complications of pulsed dye laser treatment may occur when treating hair-bearing areas, especially in dark-haired individuals, as there can be a decrease in hair or permanent hair loss. This can occur more often in younger children and in areas whereby skin is thinner such as the eyebrow and overlying bony prominences. Redarkening of the PWB can occur after lightning with laser treatment. The redarkened areas are often still improved and lighter in appearance than the original PWB.[18]

The settings used for an individual depend on a multitude of factors specific to the patient and equipment being used. Patient-specific factors include patient age, location of treatment, intensity of lesional color, number of treatments performed, and skin color. Specific equipment parameters such as make and model of laser device, age of machine, recent maintenance of laser can also all effect laser settings selected. Settings can vary greatly and therefore can be difficult to extrapolate from one laser type to another or from the literature, even if the laser is of the same wavelength. Therefore, the suggested laser settings from the literature are provided with their references with these words of caution, and advice to monitor tissue response and clinical endpoints.

Proposed settings for the treatment of PWB are 7 to 10 mm spot size, 8 to 12 J/cm^2, pulse duration of 0.45 to 6 ms, and cooling with a burst of cryogen spray of 20 to 30 ms with a 30 ms delay between the end of the cryogen spray and repeat firing of the laser. In darker-skinned individuals use of dynamic cooling has minimized side effects from laser treatment, but also using longer pulse duration/pulse width, larger spot size, and initiating treatment at a lower fluence may be appropriate to decrease potential side effects of the laser such as hypo or hyper-pigmentation and scarring.[13,14] In one study in Indian patients, Fitzpatrick skin type IV to V settings proposed were; spot size 7 to 10 mm and depending on situation 0.45 ms at 6.5–8 J/cm^2, 1.5 ms at 8 to 12 J/cm^2, 3 ms at 8 to

12 J/cm^2, and 10 ms at 10 to 15 J/cm^2.[13] For infants, laser parameters may also have lower fluences due to thinner epidermis, and smaller pulse durations due to decreased caliber and dilatation of ectatic vessels. To deliver even pulses throughout the entire lesion it is recommended that there be a 10% to 30% overlap between the pulses. "Stacking" of pulses should be avoided as it may lead to more adverse effects. The laser should also be held perpendicular to the skin being treated to prevent epidermal injury in the shape of an arcuate epidermal burn due to a misallignment in contact of the laser and cryogen cooling spray with the skin.[19]

REFRACTORY PORT-WINE BIRTHMARKS

PWB that are refractory to pulsed dye laser treatment may benefit from a longer wavelength laser (Alexandrite, 755 nm) or a combined approach with shorter and longer wavelength lasers (PDL + LP Nd Yag) to target deeper and larger caliber ectatic vessels. These lasers have a 50% to 75% increase in-depth that they can penetrate. Suggested laser parameters for Alexandrite laser for refractory PWB are spot size 8 to 12 mm, pulse duration 3 ms, cryogen spray of 40 to 60 ms with a 40 ms delay, and fluence range of 35 to 100 J/cm^2 with most fluences between 60 and 85 J/cm^2.[20] Caution is advised, as longer wavelength lasers, especially LP Nd Yag,[21] have narrower therapeutic windows and have a higher risk of adverse effects, such as deep thermal burns and scarring; therefore, they should be carefully selected with shared decision with family and patient. Additional treatments have been described such as using adjuvant posttreatment anti-angiogenesis agents such as topical rapamycin, an mTOR inhibitor that inhibits angiogenesis induced by laser vessel damage.[22] Rapamycin has been shown to be beneficial in some patients and clinical trials, but has not been universally effective.[23] One proposed treatment regimen includes treatment with once-a-day topical application of 1% rapamycin for up to 12 weeks following laser treatment.[24]

Spider angiomas

Spider angiomas (SA) are benign telangiectasias that have a central feeder vessel with fine dilated radiating vessels branching outward from the center. They are common and occur in approximately 10% to 15% of healthy children and adults. Various laser treatments have been described, with pulsed dye laser being the most common. PDL has been shown to be an effective laser to treat SA with clearance noted to be near 90% after 1 treatment and 91% after 2 treatments,[25] but KTP and intense pulsed light (IPL) laser have also been used effectively to treat SA.[26,27] Treatment parameters are as follows: PDL, 595 nm, spot size 7 mm, Fluence 40 J/cm^2, pulse duration of 3 ms, 30/20 cooling.[25] PDL settings can be adjusted to account for smaller spot size depending in the size of lesions and small pulse duration due to caliber of telangiectasia. If either of these settings is adjusted the fluence will also need to be adjusted. KTP 532 nm, spot size 2 mm, 10 to 12 J/cm^2, pulse duration of 10 to 14 ms[26] and IPL with cooling tip 550 nm, 25 to 27 J/cm^2 and 5 ms pulse duration.[27]Of note, when using IPL, the handpiece is often much too large for the size of the SA; therefore, a cover should be used to protect unaffected skin.

Infantile hemangiomas

Infantile hemangiomas are benign vascular tumors that derive from the proliferations of endothelial cells. A majority of infantile hemangiomas do not require treatment, but a minority due to functional impairment, disfigurement/risk of disfigurement, or ulceration. The use of propranolol, a beta-blocker medication, is considered first-line therapy for large or complex lesions. Laser can be a play a primary role for small and relatively flat lesions,[28] and an adjuvant role to beta-blocker treatment. Early treatment of infantile hemangiomas can prevent growth and accelerate the transition to plateau or involution phase and decrease disfigurement.[29] Suggested laser settings 595 nm, 10 mm spot, Fluence 7.75 to 9.5 J cm,[2] pulse duration 1.5 ms, dynamic cooling 30/20[16]. When treating infantile hemangiomas low fluences were used and would recommend against any stacking or overlap of pulses due to risk of ulceration, PDL laser treatment in combination with Propranolol[30] and used in combination with timolol[31] were shown to be more effective than monotherapy with any one treatment modality. Pulsed dye laser can also be used for the treatment of ulcerated hemangiomas (suggested laser settings 595 nm, 10 mm spot, Fluence 5–7 J cm,[2] pulse duration 1.5 ms, dynamic cooling 30/20) and for the residual telangiectasias and fibrofatty residua[32] (Suggested settings, CO2 fractionated ablative laser, 5%–10% density, 20 mJ) of involuted hemangiomas. Hemangioma skin can be more vulnerable to erosion, ulceration, and scarring after laser treatment than capillary malformations, so caution is advised and conservative parameters are recommended when treating hemangiomas with laser.

Angiofibromas

Angiofibromas are erythematous papules located on the central face. They can occur as isolated

lesions, or more commonly arise as a cutaneous manifestation of tuberous sclerosis. Angiofibromas are one of the earlier signs of tuberous sclerosis and can begin to appear as early as 2 to 5 years of age. Angiofibromas can be treated with pulsed dye laser, KTP laser, as well as CO2 ablative fractionated laser. KTP and PDL (suggested settings 595 nm, 10 mm spot, 7.5–9 J/cm^2, 1.5 ms pulse duration, 30/20 dynamic cooling)[33] laser treatments are more effective with smaller and more vascular appearing angiofibromas, while CO2 (10,600 nm, 5 mm spot, 0.1-second repeat, fluence 125 mJ/3.5 W, 5%–6% density) laser can be more effective for larger (>4 mm) and less vascular appearing angiofibromas. Laser treatment can be used in combination with, topical rapamycin, an mTOR inhibitor, which has been shown to be effective in treating and preventing further angiofibromas in TS.

Venous malformations and glomuvenous malformations

VM (VM) and glomuvenous malformations (GVM) are congenital vascular birthmarks that are not always apparent at birth. Over time they increase in size and can be complicated by pain secondary to thrombosis, swelling, and erythema. GVM develop in new locations over time are more superficially located and can be quite painful. There are various treatment modalities that can be used for VM including sclerotherapy, excision, glue excision,[34] medical treatment, and laser surgery. Laser can be used as a monotherapy or in conjunction with other treatment modalities. The laser should be chosen based on the depth of the VM or GVM, with shorter wavelengths, PDL, used for more superficial VMs and Alexandrite (755 nm, spot size 3 mm, 44 J/cm^2) and LP Nd Yag (1064 nm, 4–6 mm spot size, pulse duration 25–40 ms, fluence 35–70 J/cm^2) laser used for nodular VMs, VMs located in the dermis or subcutaneous fat, or GVMs. Alexandrite and LP Nd Yag lasers[35,36] can be used in combination with PDL and it is recommended that laser pulses have minimal overlap.

Lymphatic malformations

Lymphatic malformations (LMs) are congenital vascular anomalies comprised of malformed, dilated, and disorganized lymphatic channels. LMs can be characterized as macrocystic, microcystic, or combined. Treatment of LMs can be conducted with LP Nd Yag and LP Alexandrite lasers especially if there is a hemorrhagic component present within the blebs. CO2 (10,600 nm, ablative fractionated laser, 25 mJ, 2 passes, 10% density)[37,38] ablative laser may also be used in cases whereby there is a lack of a hemorrhagic component to target.

Laser treatment for pigmented lesions

Becker nevus

Becker nevus (BN) is an organoid hamartoma characterized by a segmental area of hyperpigmentation and hypertrichosis most commonly located over the shoulder, chest, and scapula. It often appears in adolescence, but congenital cases have been described. Laser treatments are aimed at either hyperpigmentation, using QS lasers or fractionated ablative lasers, or hypertrichosis using laser hair removal devices which are generally Alexandrite (755 nm) or Diode (810 nm) for individuals with lighter hair and LP Nd Yag (1064 nm) for individuals with darker hair.[39]

Melanocytic nevi

The removal of melanocytic nevi in children with laser therapy is controversial and is generally not recommended.

Congenital melanocytic nevi

Laser treatment for the removal of Congenital Melanocytic Nevi (CMN) is also not recommended. However, laser hair removal has been reported to be effective for the treatment of hypertrichosis with a CMN. The cutaneous features of a CMN with increased nodularity and rugosity can make it difficult to shave or precisely clip the hair, therefore, making laser hair removal an effective option. There have not been any reports of malignant transformation of the CMN after laser hair removal techniques.[40] The final coloration of the CMN also does not seem to be altered by laser treatment.[41]

Nevus of Ota/Nevus of Ito

Nevus of Ota and Nevus of Ito are forms of dermal melanocytosis located specifically around the eye and face in Nevus of Ota and along the arm/shoulder for Nevus of Ito. The QS lasers have been effective in treating these conditions and early treatment is associated with better results.[42,43] If treating within the orbital rim a metal corneal eye shield will need to be placed with topical ophthalmic anesthetic drops and nonflammable lubricating gel.

Laser treatment for other conditions

Keratosis pilaris rubra

Keratosis pilaris (KP) is a common skin condition characterized by follicular plugging affecting the cheeks, lateral arms, and proximal thighs. It is often accompanied or background erythema, termed Keratosis Pilaris Rubra (KPR). Treatment of KPR is

Table 3
Indication for use of lasers in pediatric dermatology

Laser Type (Wavelength nm)	Target (Chromophore)	Indication	Expected Endpoint
Excimer (308 nm)	Nonspecific	Vitiligo, Psoriasis, Atopic Dermatitis, Alopecia Areata	None
KTP Long Pulsed (532 nm)	Hemoglobin	Angiofibroma, Spider angioma, Telangiectasias	Disappearance of the vessel, coagulation of the vessel or lesion
KTP QS (532 nm)	Melanin	Café au lait macules, ephelides	Immediate whitening
Pulsed Dye Laser (585–600 nm; 595 nm most common)	Hemoglobin	• Vascular lesions: Port wine birthmarks, facial telangiectasias, spider angiomas, Infantile hemangiomas • Keratosis Pilaris Rubra Erythematous scars/ striae • Warts	Purpura, vessel disappearance, vessel darkening
Long-Pulsed Ruby (694 nm)	Melanin	Hair removal	Erythema, mild perifollicular edema
QS Ruby (694 nm)	Melanin	Nevus of Ota/Ito, dermal pigment	Immediate whitening
Long-Pulsed Alexandrite (755 nm)	Hemoglobin	Hypertrophic or PDL refractory PWB, laser hair removal	Purpura after 5 min or more (PWB), erythema and perifollicular erythema (hair removal)
QS Alexandrite (755 nm)	Melanin	Nevus of Ota/Ito, dermal pigment, café au lait, Becker's nevus	Immediate whitening
Diode (800 nm)	Deoxyhemoglobin	Hair removal	Erythema, mild erythema, and perifollicular erythema (hair removal)
Long-Pulsed Nd Yag (1064 nm)	Deoxyhemoglobin, Melanin	Hair removal, venous malformations, glomuvenous malformations, PDL resistant PWB and hypertrophic PWB, warts	
QS Nd Yag (1064 nm)	Melanin	Nevus of Ota/Ito, dermal pigment, Becker's nevus	
Erb: Yag (2940 nm)	Water	Ablation of epidermal lesions, skin resurfacing, scars, acne scarring	Pinpoint columns of destruction (fractionated); Full-field ablation
CO2 (10,600 nm)	Water	Ablation of epidermal lesions, skin resurfacing, scars, acne scarring	Pinpoint columns of destruction (fractionated); Full-field ablation

Adapted from Lehmer and Kelly "Laser surgery" Procedural Pediatric Dermatology, Edition 1[48–50].

often disappointing with the use of topical emollients, topical keratolytics, topical retinoids, and topical anti-inflammatory agents such as topical calcineurin inhibitors and topical corticosteroids that have shown little effect for the erythema. There have been case series looking at laser treatment of KPR.[44] For maintenance of results treatment must be continued or lesions and the erythema will often occur. Out of all laser treatments discussed in the literature, pulsed dye laser has been shown to be most effective with longer lasting improvement and decrease in recurrence. Suggested laser settings with PDL, 595 nm, spot size 7 to 10 mm, fluence 4.5 to 11.5 J/cm^2 (most treated with 8–11.5 J/m^2), pulse duration ranged from 1.5 to 10 msec (most treated with a pulse duration of 1.5 or 3 msec), and dynamic cooling 30/20[44].

HIDRADENITIS SUPPURATIVA

Hidradenitis suppurativa (HS) is a chronic follicular disease that causes painful inflammation, scarring, draining nodular and sinus tracts with predilection for intertriginous areas. Most patients present after puberty. There is a broad range of medical and surgical therapies for HS. Laser hair removal works best as adjuvant therapy and has been effective by causing follicular destruction. Primary endpoints observed for the laser include perifollicular erythema and edema. The scarring sinus tracts are not effectively treated with laser, but individuals with recurrent nodules and abscesses, which tend to be a marker of active follicular disease, tend to have the best results from laser therapy. The treatments focus on destroying hair follicles and debulking lesions through ablation. A variety of lasers have been described in the treatment of HS including LP Nd Yag, IPL, Alexandrite, Diode, and CO2 ablative lasers.[45]

WARTS

Warts are caused by human papillomavirus (HPV). Laser treatment is one therapy that can be used for recalcitrant warts. Pairing the wart before the procedure makes the laser procedure more effective. Application of topical lidocaine before treatment makes the treatment more tolerable and can also make paring of the wart easier by softening the wart. In addition to laser-appropriate eye protection, a smoke evacuator and a surgical or charcoal mask should be used for laser due to the potential aerosolization of HPV during the procedure.[4] Laser treatment with PDL (595 nm, spot size 5–7 mm, Fluence 9–14 J/cm^2, pulse duration 0.45–1.5 ms, no cooling for nonfacial warts) should include 1 to 2 mm of normal skin around the wart for the zone of treatment. LP Nd Yag laser can also be used for the treatment of warts (1064 nm, 3–6 mm spot size, 180–300 J/cm^2 pulse duration 20 ms, no cooling for nonfacial warts).[46] CO2 laser can also be used to treat warts. Both of the above-mentioned settings are for nonfacial warts and again the treatment parameters are difficult to apply to other laser machines. For the treatment of warts on the face, dynamic cooling is used and lower fluence and spot size matching size of the wart.[47] If the clinical endpoint of purpura is not achieved, up to 3 passes over the wart can be performed. Treatment can be repeated every 4 to 6 weeks.**Table 3**

CLINICS CARE POINTS

- Lasers can treat a wide variety of conditions within pediatric dermatology with significant benefit and limited morbidity
- Early initiation, less than 6 months of age, of laser treatment of PWB has improved outcomes
- Use of larger spot sizes, decreased fluence, dynamic cooling longer pulse durations can minimize adverse reactions to laser therapy for darker-skinned individuals.
- Laser settings cannot be generalizable across all device types for a specific wavelength of laser.
- Monitoring tissue response and clinical endpoints are important to assess the efficacy of the treatment and allow for intraoperative fine-tuning of laser parameters

DISCLOSURE

The authors have nothing to disclose.

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