Nd:YAG Laser Therapy

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12.1 Brief Description of the Method

Selective thermal destruction of blood vessels, hair roots, fatty tissue deposits, sebaceous gland growths, and viral warts of the skin occurs by means of long-pulsed laser radiation in the infrared wavelength range (1064 nm).

12.2 Indications

Medical as well as aesthetic indications in dermatology include:

- Vascular malformations (nevus flammeus).
- Vascular neoplasms (hemangioma and telangiectasias).
- Vascular dilatation (venous lake, veinectasia, varicose veins), Fig. 12.1.
- Unwanted Hypertrichosis.
- Hirsutism.
- Verrucae vulgares.
- Xanthelasma.
- Sebaceous gland hyperplasia.

They are shown in detail in Table 12.1.

For the treatment of hypertrichosis and hirsutism, the Nd:YAG laser occupies a special position among the devices available for photoepilation, since its low absorption in melanin means that it can also be used without any problems with pigment types III to VI. This advantage is also used in the treatment of vascular anomalies on tanned skin.

12.3 Physical and Medical Basics

The principle of selective photothermolysis allows the selective destruction of blood vessels, hair roots, or fatty tissues by means of photon emission in certain wavelength ranges (in the case of the Nd:YAG laser 1064 nm) through targeted heating of selected chromophores.

Of particular importance in this application is the prior, parallel, and subsequent cooling of the epidermis and the tissue structures surrounding the target structures in order to avoid their thermal co-damage.

The use of Nd:YAG lasers with sufficiently high power output in pulsed form is a prerequisite for this treatment method due to the low absorption in hemoglobin, melanin, or fat. In contrast to the other vascular lasers (argon laser, KTP laser, pulsed dye laser (Chap. 11), diode lasers, alexandrite lasers), Nd:YAG lasers need 10 times higher fluences for sufficient heating of the blood vessels and for thermal damage of the follicles 2 to 3 times higher energy densities.

This lack of absorption is compensated by the considerably higher penetration depth of the

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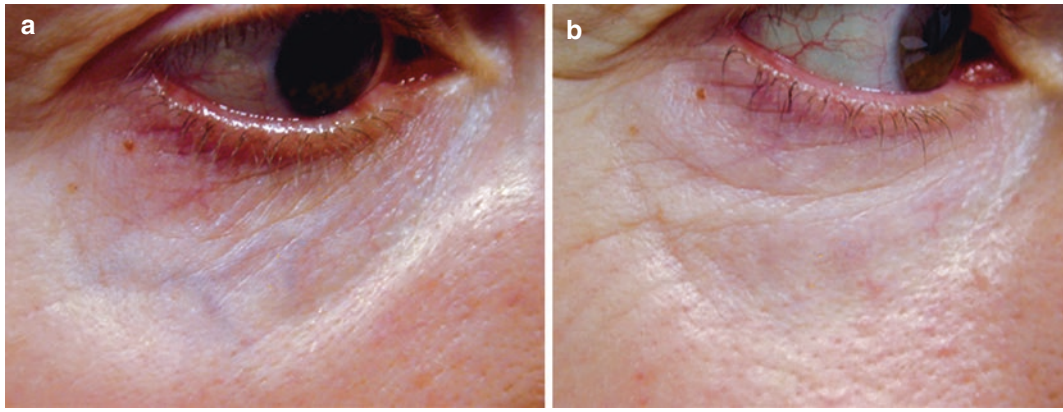

Fig. 12.1 (**a**, **b**) Removal of dilated veins periorbital (**a**) before and (**b**) 1 year after two treatments with the Nd:YAG laser. (From Drosner 2015)

Table 12.1 Indications for Nd:YAG laser therapy in dermatology with evaluation of medical/therapeutic results

Indication	Therapeutic outcome
Port-wine stain	
Port-wine stain, bright red and flat (in combination with pulsed dye laser, Chap. 12, or selective waveband technology [SWT, flash lamps, Chap. 12])	+–++
Port-wine stain, dark to livid red	++–+++
Port-wine stain, tubereous	+++
Hemangioma	
Angioma, eruptive (senile)	+++
Angiokeratoma	+++
Hemangioma, early childhood	++
Hemangioma in vascular malformations	+++
Lip angioma (venous lake)	+++
Telangiectasia	
Spider vein	++
Nevus araneus	++–+++
Rubeosis (couperosis)	–
Telangiectasia, light red	++
Telangiectasia, dark to livid red	+++
Varicose vein, reticular	+++
Vein ectasia	+++
Hypertrichosis/hirsutism	
Dark brown, thick hair on light skin	+++
Dark brown, thin hair on light skin	++
Light brown, thick hair on light skin	++
Light brown, thin hair on light skin	–
Dark brown, thick hair on dark skin	+++
Dark brown, thin hair on dark skin	++
Light brown, thick hair on dark skin	++
Light brown, thin hair on dark skin	
Other	
Warts	+–+++
Sebaceous gland hyperplasia	++–+++
Xanthelasma palpebrarum	+–+++
Collagen neogenesis	+

+++ excellent, ++ good, + moderate

Nd:YAG laser radiation into the skin. On the other hand, the lower absorption also leads to slower and more comprehensive coagulation of the target structures. These physical characteristics of the Nd:YAG laser radiation allow both sufficient coagulation of larger vessels in deeper skin sections, but they are also the reason for the higher potential of side effects when used imprudently or improperly.

The Nd:YAG laser is rightly described as the most dangerous laser in the dermatological field.

12.4 Practical Implementation

Vascular Treatment

Pretreatment

Due to the low absorption in melanin, skin type and degree of tanning are of secondary importance when treating vessels with a Nd:YAG laser. However, the areas to be treated should be free of make-up and free of hair (the high-energy Nd:YAG laser light ignites hair!). A surface anesthesia (e.g., EMLA Cream®, PLIAGLIS Cream®, or a 30% lidocaine formulation) may be necessary for the treatment of pain-sensitive patients or children. In the case of vascular malformations (tuberous manifestation), especially in childhood, general anesthesia or analgosedation with laughing gas may be advisable.

Treatment Process

Parameter Selection

Before the actual laser treatment, the physician has to select the appropriate parameter for treating a nitrous oxide vascular disorder.

As a rule of thumb, small or bright red vessels or hemangioma are treated with the smallest possible spot size (1–3 mm), shorter pulse durations (6–20 ms), and higher fluences (200–400 J/cm^2), while bluish-red, thicker vessels or hemangioma (2–3 mm in diameter) should be treated with larger spot sizes (3.5–5 mm), longer pulse durations (20–50 ms), and lower energy densities (80–200 J/cm^2).

The diffuse and deep absorption of the Nd:YAG laser light allows the application of unusually small beam diameters, which are not very promising for other laser beams due to their scattering and limited penetration depth. The use of 1 to 3 mm spot diameters is sufficient for the treatment of superficial telangiectasias and spider veins, while 4–7 mm spot sizes are more suitable for the coagulation of larger volumes (hemangiomas or reticular leg veins).

Pre-Treatment (Pre-Cooling)

After setting the parameters on the device and checking whether everyone in the room is wearing the correct safety glasses, a thin layer of ultrasound gel is applied (better penetration of the laser radiation plus additional cooling of the surface!), and then the area to be treated is precooled for a few seconds. For devices with contact cooling, the handpiece of the Nd:YAG laser with its cooling plate must be pressed firmly onto the treatment site for a few seconds. As an alternative to contact cooling, there are also Nd:YAG lasers with air cooling that blow cold air directly onto the treatment surface via a nozzle.

Test Treatment

After precooling, the laser with the pilot beam is directed at the vessel to be treated and the laser pulse is triggered (after "pre-warning" the patient). Immediately after the test shot(s), the area should be cooled again for a few seconds. The reaction of the vessel is observed during the laser treatment as well as after post-cooling. It is examined whether the blood in the vessel has changed the color (from red to bluish) or the blood is squeezed out by heat contraction of the vessel wall or if the blood can still be pushed away or will fill up again after a short push. At the same time, the patient is asked about pain. Using a Nd:YAG laser with permanent air cooling, the vessel response can be observed during cooling. With contact cooling, the handpiece with its cooling plate has to be placed onto the treated vessel right after the shot. Therefore immediate reactions of the treated vessel might be missed.

Treatment

If the parameter selection was correct, further impulses can be applied (if necessary after further pre-cooling) until the entire surface (e.g., the entire vessel in its course) has been treated. The impulses are placed next to each other without overlapping and in distance of the selected spot size. If a bluish coagulation, a purging of the vessels due to thermal constriction or at least the arrest of the blood flow can be seen in all vessel sections, the treatment is completed.

While with single thin vessels or small hemangioma, the same place can be treated several times up to sufficient coagulation (maximum three times after sufficient intercooling!); with large-volume vessels or larger hemangioma, multiple treatment in the same session should be avoided.

In order to avoid overtreatment, it is better to wait at least 4 weeks for the treatment to take effect. As the Nd:YAG laser light has a much stronger absorption with larger volumes than with small structures, the follow-up time should exceed 4 weeks after the treatment of larger chromophores.

CAVE: After multiple shots on larger vessels, the thermal damage would no longer be limited to the blood vessel wall but would also extend to the surrounding tissue structures (connective tissue). The result could be atrophic scarring.

Posttreatment (Post-Cooling)

Immediately after completion of the treatment, the laser device is switched to standby and a moist compress or a knotted surgical glove filled with cold water (4–8 °C, refrigerator) is applied to the patient for post-cooling (Fig. 12.6). If a compress from the freezer compartment of the refrigerator is used, it must not be applied directly to the skin. A cold air unit can also be used for aftercooling. To avoid the risk of a frostbite during cooling with cold air, the patient or the practitioner attending to the patient should constantly move the cold air nozzle back and forth or keep it at a distance of at least 30 cm. Alternatively, the cold air nozzle can also be held at a distance by using a tripod with low air circulation.

CAVE: As the cold airflow has an anesthetic effect, the patient would not notice the freezing.

Healing Process and Restrictions After Treatment

After Nd:YAG laser treatment, the treated skin areas temporarily (30–60 min) are reddened and swollen like in urticaria. Often an unpleasant itching occurs for 30 min. Sometimes an edema is visible the next day, which disappears completely in a few days.

Direct sun exposure should be avoided until all therapy-related changes have healed; otherwise, the risk of postinflammatory hyperpigmentation is increased.

Appropriate sunblock creams (LSF 50+) should be used every day during healing time. As Nd:YAG laser treatments with adequate cooling usually do not cause any surface damage, the treated skin area can be covered with make-up immediately after the treatment. With the exception of small hematomas and their absorption in the course of 2 weeks, there are no significant limitations after Nd:YAG laser treatments. The patient should be instructed to contact the physician if any abnormalities (blister bladder and erosion formation, oozing) occur during healing. Sometimes hyperpigmentation (hemosiderin deposition) is observed for weeks or rarely months.

Continuation of Treatment

Further treatment sessions can be scheduled 4–8 weeks later. The healing of spider veins often takes 2 to 3 months (Fig. 12.2).

Epilation Treatment

In general, the treatment procedure of photo epilation with the Nd:YAG laser is largely similar to the treatment of vascular disorders. In the following, therefore, only the deviations from the procedure for vascular indications will be presented. In general, photoepilation treatment requires more preparation than vascular treatment.

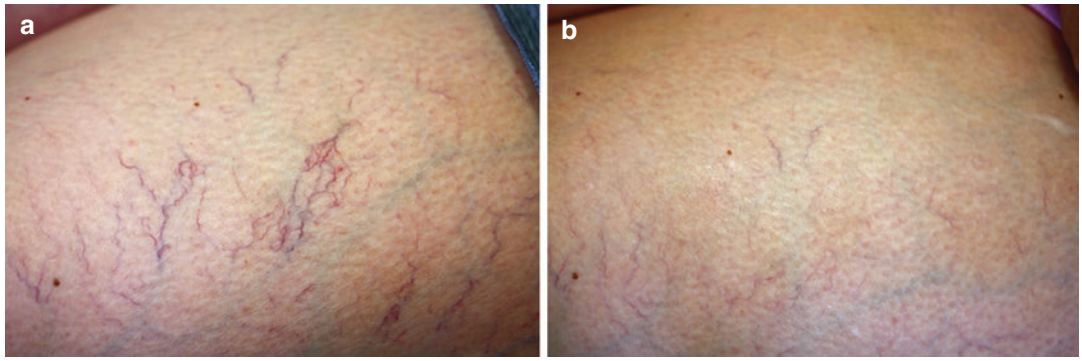

Fig. 12.2 (**a**, **b**) Before (**a**) and 21 weeks (**b**) after treatment with the Nd:YAG laser treatment of spider veins on the thigh; parameter: 3 mm, 16 ms, 199 and 252 J/cm^2 respectively. (From Drosner 2015)

Pretreatment

Field Marking

Hairless surface is particularly important in photo epilation treatment. However, it is recommended that patients present themselves either not shaved at all or at least with 1 mm length of hair before treatment, so that the treatment area can be better defined (to avoid unnecessary treatment of hair-free areas) and the thickness of the hair is visible to select the treatment parameter accordingly. The treatment area can be framed on the skin with a white grease pencil (Kajal). The color of the frame must not take up laser light! Colored markers other than white might absorb the laser light to varying degrees and can lead to superficial burns with the risk of (permanent) postinflammatory hyperpigmentation.

In addition, the area with the strongest and densest hairs should be marked. After shaving, the remaining hair cuttings are picked up from the treatment area using plaster strips in order to prevent inadvertent heating of the pigmented hair remains at the surface of the skin (which may cause branding with pain, prolonged healing, and postinflammatory hyperpigmentation). Less experienced practitioners can then use the white grease pencil to mark thin auxiliary lines in order to divide large areas to prevent double treatment or skipped treatment areas.

Anesthesia

Since thermal damage beyond the hair system during treatment is always indicated by severe pain, anesthesia of any kind during epilation treatments is not indicated. Instead the patient is encouraged to report excessive pain (the first sign of overdosage).

Lubricant

The area of photoepilation (in case of larger areas first parts of it) is coated with a thin layer of ultrasound gel before the laser treatment. This serves to reduce light scattering and will improve the cooling of the junction zone. It also facilitates the even crossing of the treatment area in the contact procedure. To further improve light penetration, the patient should use hydrating cream on the morning of the treatment day.

Treatment Process

Parameter Selection

The operator must also determine the appropriate parameters before the epilation treatment. As a rule, photoepilation is started with the following parameters: spot size 10 mm, pulse times 15–20 ms (the finer the hair, the shorter the pulse time should be, up to 10 ms or shorter), energy density 45 J/cm^2.

Pre-Cooling/Sample Treatment

After setting the parameters on the device, checking the safety goggles and applying the lubricant

gel, a suitable place for test treatment is selected. For this purpose, the most dense hairy area should be addressed (see marking). After a short precooling, 1–2 test pulses are emitted in this area. The patient is asked about pain. If he did not feel anything from the treatment, the energy density can be increased up to a still tolerable pain with further test pulses.

For difficult epilation treatments (chin epilation, epilation of light or thin hair, dark pigmented, or tanned skin), the immediate treatment reaction of the follicle should be waited 5–10 min. If a follicular bound erythema and/or edema develops, it can be assumed that the hair system is heated sufficiently.

However, if a confluent erythema forms between the treated follicle openings, this indicates that the thermal load on the epidermis is too high and the pulse length should be increased.

If the perifollicular edema converges, it can be assumed that the tissue surrounding the hair follicles is subjected to excessive thermal stress. In this case, the energy density must be reduced.

Treatment

If the parameter were selected correctly, the entire area can now be treated. For this purpose, the laser cooling handpiece is continuously moved over the skin, with the cooling surface ahead. The laser is set to a repetition mode of 1.5–3 Hz (depending on the practitioner's routine), and the treatment area is then processed in strips, whereby both the individual impulses and the individual strips may overlap by about 10%.

Posttreatment

Cooling

It is even more important than after the vascular treatment to give the patient a moist or cold compress (cold pack) or the cold air described above for aftercooling immediately after the epilation treatment while the laser is switched to standby.

The patient should not be discharged from the practice until all symptoms of the thermal side effect (reddening, burning) have completely disappeared.

Course of Treatment/Restrictions After Treatment

As a rule, the treated areas are neither reddened nor do they show edema 30 min after the laser treatment. Should this nevertheless be the case, further cooling measures are absolutely necessary. The treated area should not be exposed to direct sunlight for 1–2 weeks (risk of postinflammatory hyperpigmentation). Appropriate sunblock creams (LSF50+) should be used during the day if sun exposure cannot be avoided.

Continuation of Treatment

Depending on the progress of the epilation treatment or the treatment region, hair growth can be expected to resume in 4–8 weeks. As soon as the regrowing hair can no longer be easily pulled out of the skin ("like pulled out of butter"), the next treatment session should take place.

As a rule, 5–8 repeat treatments are necessary in order to achieve a lasting epilation effect. However, the response rate cannot be predicted in general and must always be clarified individually by appropriate trial treatments.

Of course, the patient must not remove the regrowing hair by plucking between treatments, as the pigment-bearing roots of the regrowing hair in turn serve as a chromophore for the next treatment.

Hypertrophic Sebaceous Glands and Xanthelasma/Xanthoma

Due to the (low) absorption of Nd:YAG light in fatty tissue and the greater depth of these tissues, larger beam diameters (>2 mm), longer pulse times (>15 ms), and higher energy densities (>300 J/cm^2) are required for the treatment of sebaceous gland hypertropia (Fig. 12.3), and xanthelasma or xanthoma (Fig. 12.4) is necessary. In contrast to vascular treatment, the endpoint of the treatment is more difficult to assess. Occasionally one sees a small (whitish) brightening of the yellowish tissue color. Even if there is no tissue reaction, multiple treatment in the same treatment area should be avoided in

Fig. 12.3 (**a**–**h**) Hypertrophic sebaceous glands. (**a–c**) Before treatment. (**d**) 5 weeks after Nd:YAG laser (Candela/Ellipse-Nd:YAG™) 1.5 mm, 20 ms, 390 → 440 J/cm^2. (**e**, **f**) Immediate brightening of the sebaceous gland hypertrophia after Nd:YAG laser treatment. (**g**, **h**) 2 months after the third Nd:YAG laser treatment (Candela/Ellipse-Nd:YAG™) 1.5 mm, 20 ms, 390 → 480 J/cm^2. (From Drosner 2015)

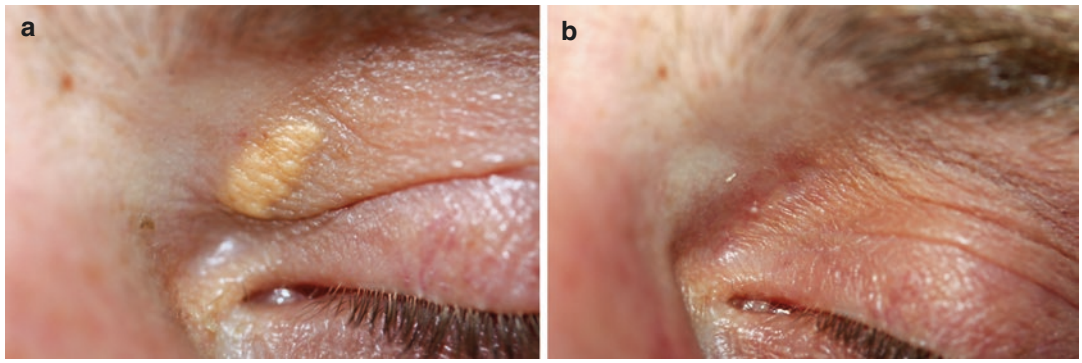

Fig. 12.4 (**a**, **b**) Xanthelasma. (**a**) Before treatment. (**b**) 5 weeks after 2 × Nd:YAG lasers (Candela/Ellipse-Nd:YAG™) first treatment: 2.5 mm, 15 ms, 330 → 350 J/cm^2, second treatment: 2.5 mm, 20 ms, 400 J/cm^2. (From Drosner 2015)

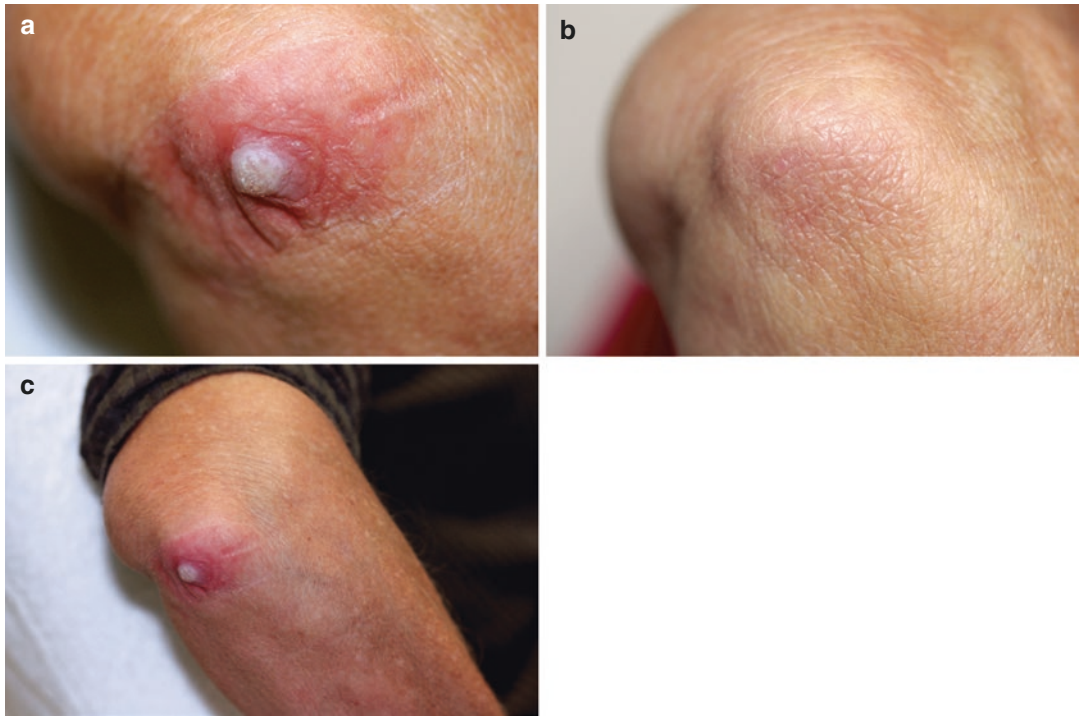

Fig. 12.5 Viral wart. 22 months after 1 × Nd:YAG laser (Candela/Ellipse-Nd:YAG™: 5 mm, 20 ms, 200 J/cm^2 9 pulses, after keratolysis and infiltration anesthesia with lidocaine 2% + A). (From Drosner 2015)

order to prevent overtreatment resulting in an atrophic scar. As a rule, two to three treatment sessions at monthly intervals are necessary. Sometimes the absorption of the Nd:YAG radiation is too low, so that no treatment success is achieved. This should be communicated to the patients before the treatment. Nevertheless, the thermal treatment and stimulation of the regression of these fatty tissues are a quasi-noninvasive procedure and thus clearly superior to surgical correction.

Viral Warts

Viral warts (resistant to keratolysis and other basic treatment options) can be successfully treated with the Nd:YAG laser. For thermal destruction of warts, higher penetration depths (3.5 up to 5 mm spot size), longer pulse times (15 to 20 ms), and higher energy densities (> 300 J/cm^2) are necessary. However, since tissue contaminated with viruses is more vascularized and therefore the Nd:YAG light causes painful thermal damage, the treatment might be performed under local anesthesia (which is painful, too). Due to the absorption of Nd:YAG light in blood and tissue water, the application should be limited to a maximum of 4 pulses per spot (or per viral wart) to prevent atrophic scarring. A second treatment session can take place after 4 weeks at the earliest (Fig. 12.5).

12.5 Contraindications, Contraindications

Vascular Contraindications

In the case of blood coagulation disorders, larger vascular malformations should not be treated with Nd:YAG lasers, as there would be an increased risk of bleeding due to the unsafe coagulation.

Nd:YAG laser therapy is not suitable for the following vascular disorders:

- Rubeosis or homogeneous erythema.
- Light red or pink port-wine stains.
- Matting.

Contraindications for Photoepilation

Due to the unclear role of stem cells in tissue differentiation, children should only be treated for epilation under restricted indications. Nd:YAG laser therapy is unsuitable for epilation of light (blond, white) or very thin hair. The moles in the treatment field (nevus cell nevi) should be omitted or covered during epilation treatment, as there is uncertainty about a possible induction of malignancy. The desire for extensive hair removal of the scalp hair should be met with caution.

Fatty Tissue Neoplasms or Deposits

Care must be taken to ensure a reliable clinical diagnosis, especially of xanthomas. In case of doubt, the diagnosis should be confirmed by biopsy to exclude malignant tumors (e.g., basal cell carcinoma).

12.6 Side Effects

Due to the relatively low absorption of Nd:YAG laser radiation in melanin, treatment errors with too high energy density unfortunately do not show as grey discoloration or blistering in the epidermis, as is known from most other dermatologically effective laser systems. Rather, the side effects are directly related to the **dermis** and are related to the absorption of Nd:YAG laser radiation in water. In case of unintentional overdosage, a diffuse overheating of the connective tissue occurs with the consequence of a loss of substance in the form of **atrophic scarring** in the healing process. Bubble formation in the junction zone is more secondary (caused by heat rising from the upper corium) and therefore leads to hypopigmentation and whitish to atrophic scars (Fig. 12.6 and Fig. 12.9).

Without the impact on the epidermis, Nd:YAG laser overdose lacks early warning signs, apart from severe and persistent pain.

First and foremost, the risk of unwanted overheating increases with the diameter of the Nd:YAG laser beam and the energy density.

Small spot sizes (1.5–2.5 mm), sufficiently long pre-cooling of the surface, longer pulse times (>16 ms), and moderate energy densities (approx. 180 J/cm^2), are helpful for a careful approach to the correct treatment parameters. If the chromophore is not heated enough, two further pulses with shorter pulse time or higher energy density can follow. If an adequate reaction could not yet be achieved, a follow-up of 4 weeks minimum should be observed before a second treatment attempt is started.

As a first aid in case of possible overdosage, continuous (possibly several days!) cooling should be carried out until the pain has subsided and does not recur even after cooling is finished. A surgical glove filled with cold water and knotted is particularly suitable for this purpose. It should be stored in the refrigerator (not in the freezer!) and given to the patient immediately after head damage. With several such water gloves, continuous cooling is easily organized (Fig. 12.7).

Burn management includes short (daily) follow-up visits, using hydrocolloid dressing whenever wet wound healing starts; signs of a secondary infection should be observed.

With regard to the indications described, the following side effects can be found.

Side Effects of Vascular Treatment

Pain, hematoma, blister and crust formation, and weeks later whitish scarring will occur as a result of unintentional burning. Rarely leg vein treatment result in enlargement of the recanalized vessels (especially possible in the treatment of spider veins of the “feeder” type). A reactive formation of fine telangiectasias in the form of diffuse erythema from fine telangiectasias (matting) may occur.

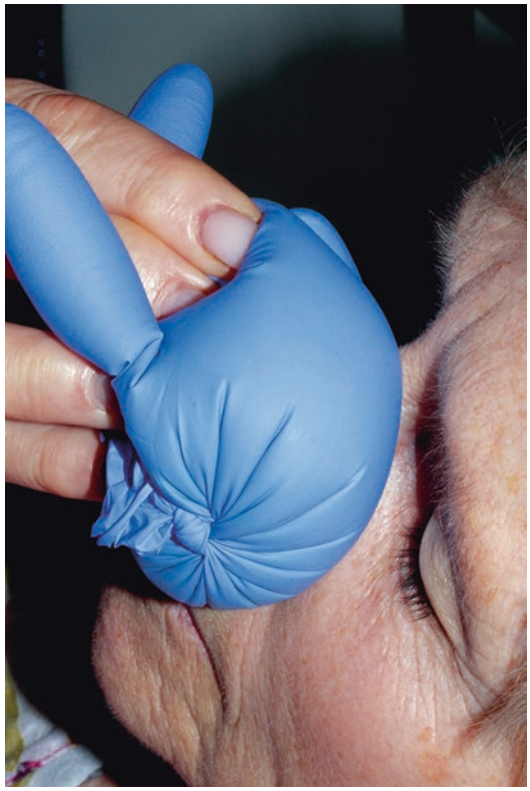

Fig. 12.6 If overdosage is possible, continuous cooling should take place until the patient is pain-free: Here through a knotted surgical glove filled with water, which is pre-cooled in the refrigerator ("vegetable compartment")

Fig. 12.7 Hypotrophic scar on the chin after hair removal with the Nd:YAG laser. (From Drosner 2015)

If too large volumes are treated with too high energy densities and at the same time (relatively) too short pulse times, the treated vessel ruptures because the vessel wall is overstretched by the rapid increase in volume of the heated blood. At the same time, insufficient heat transfer to the vessel wall occurs in these cases so that the vessel wall will be repaired. A hematoma occurs when the blood vessel is preserved at the same time, but no damage occurs in the long term.

In the treatment of spider veins, treatment intervals of at least 6 weeks should be observed in order to detect the development of less frequent side effects (hypopigmentation, matting).

Dangerous side effects with atrophic scars can actually only occur if large blood volumes are treated with too large spot seize and too high dosage.

Side Effects of Hair Removal

Pain, blistering and crust formation, and whitish scarring may arise as a result of unintentional overheating of the tissue surrounding the hair roots. In the treatment of convex body areas with dense hair, there is a risk that the same chromophores will be repeatedly heated several times. Another unpredictable side effect is the development of lighter and thinner hair, a rare stimulation of hair growth at the edge of the treatment fields.

For photoepilation in general, the dosage must always be adjusted to the area with the thickest, darkest, and densest hair.

Side Effects During Treatment of Fatty Tissues

Due to the low absorption of Nd:YAG light in fatty tissue and the resulting lack of immediate biological reaction, pulse stacking (multiple pulses per tissue unit) can easily lead to overheating and subsequent atrophic scarring (Fig. 12.8). A whitish or gray discoloration of fatty tissue is an early warning sign to stop the treatment with the selected parameters.

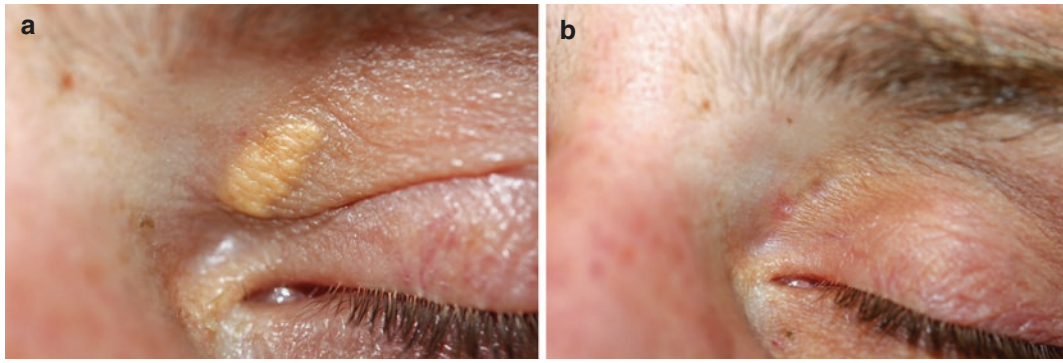

Fig. 12.8 (**a**, **b**) Xanthelasma on the left upper lid (**a**) and 10 weeks after (**b**) 2 treatments with pulsed Nd:YAG laser. A small atrophic scar has formed centrally (arrow)

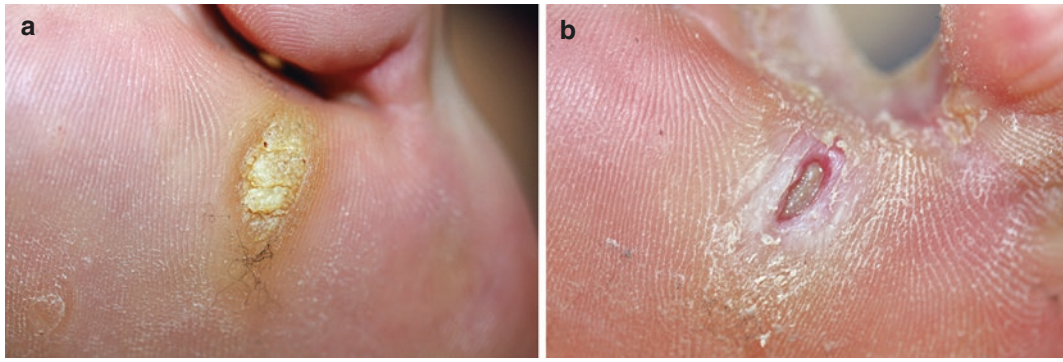

Fig. 12.9 (**a**, **b**) Hypotrophic scar plantar (**a**) before and (**b**) after Nd:YAG laser therapy of plantar warts

Side Effects During Treatment of Warts

In the case Nd:YAG laser treatment of warts is performed under local anesthesia, pain sensation as a natural protection against overdose is excluded. Therefore special attention should be paid during multiple treatment in one session, overlapping of pulses, or pulse stacking. Otherwise tissue destruction and atrophic scarring may occur (Fig. 12.9).

12.7 Information and Consent

Before laser treatment, especially in aesthetic procedures, a thorough information of the planned treatment, its risks and possible treatment alternatives must be provided (see also Chap. 12: Nd:YAG laser). Notes and sketches may complete the information (consent form) together with before-and-after images in order to better prepare the patient for possible difficulties and side effects of the treatment (insufficient effect of parameters chosen, repeated treatment, risk of scarring). This information should preferably take place at least **24 h before surgery**. It should be given to the patient in writing and separately from the treatment contract. The consent form is to sign by the patient prior to the treatment.

The following risks should be clarified to the patient before starting Nd:YAG laser therapy.

Vascular Treatment

- Ineffectiveness (in case of underdose), repeated treatments, pain, bruising, blister, scab and crust formation (by overheating the treatment area, crusts may cause repeated secondary bleeding during healing), pigment

changes with hyperpigmentation (following purpura, hemosiderin deposition, post-inflammatory hyperpigmentation may occur during UV exposure during the healing phase) or hypopigmentation (heat damage to melanocytes), purpura (caused by vessel rupture due to short pulse durations combined with high fluences if the chromophore is unexpectedly large), whitish or atrophic scarring (as a result of unintentional overheating).
- Professional musicians in particular must be informed about these risks and the associated downtime when treating lip angiomas.
- In addition in leg vein treatment, enlargement of the recanalized vessels (typically for spider veins of the "feeder" type), matting (appearance of very fine capillaries persisting as red spot).

Epilation Treatment
- Side effects in hair removal comprise pain, blister and crust formation, whitish to atrophic scarring as a result of unintentional overheating of the tissue surrounding the hair roots, insufficient effect with hair regrowth in the same density, and development of lighter and thinner hair during repeated sessions. While treating convex-shaped areas, the risk of repeated treatment of the same tissue segment arises together with overheating by unspecific absorption of Nd:YAG light in the tissue water of that segment. A further unpredictable unwanted effect is the stimulation of hair growth at the edge of the treatment field caused by the transformation of vellus hair into terminal hair as a consequence of scattered light heating.
- Post-inflammatory hyperpigmentation may occur during UV exposure during the healing phase.

Treatment of Fatty Tissues
- The low absorption may result in insufficient removal of the fatty tissues (hypertrophic sebaceous glands, xanthelasma). If the low absorption is compensated by a higher dosage or multiple treatment (pulse stagging), overheating and atrophic scarring may occur.

12.8 Equipment

Nd:YAG laser systems from various manufacturers (e.g., ALMA Lasers, Cutera, Cynosure, DEKA Laser, Fotona, Lumenis, Syneron Candela, Quanta Aesthetic Lasers) are available, all of which have the same wavelength but differ in pulse profile and total power. In addition, the industry also offers combination devices which combine two or more different wavelengths in one device (e.g., Harmony XL Pro, Alma lasers = qsw. Nd:YAG + Er:YAG + LP Nd:YAG + Er:Glass; Soprano ICE Platinum, Alma = 3 diode lasers 755 nm + 810 nm + 1064 nm; Alma Q = triple mode Nd:YAG laser with 4 wavelengths 1.064 nm + 532 nm + 585 nm + 650 nm; excel V, cutera = Nd:YAG + KTP, excel HR, cutera = Nd:YAG + Alexandrite; Cynergy, Cynosure = Nd:YAG + dye laser, Elite IQ, Cynosure = Nd:YAG + alexandrite; Synchro REPLA:Y, DEKA = Alexandrite + Nd:YAG long-pulse + Nd:YAG short pulse).

In addition to "stand-alone" devices, some manufacturers also offer Nd:YAG lasers as plug-in applicators that can be connected to a treatment console (usually an IPL device) (e.g., Nordlys, Candela; M22, Lumenis; Icon, Cynosure).

The advantage of such combination devices (base device and handpieces) is caused by the significantly wider range of indications due to the additional use of IPL and other laser applicators (e.g., a non-ablative fiber laser or a q-sw. Nd:YAG-Laser, Lumenis).

The maintenance costs are limited to the safety checks prescribed in Germany.

Treatment Room

For safety reasons, the premises in which a laser system is operated must meet certain requirements (Table 12.2).

For example, there should be no mirrors or reflective surfaces in the room to avoid the reflection of laser beams.

If windows are present, adequate protection against accidental reflection of laser radiation must be provided, e.g., a low-reflection and

Table 12.2 Treatment room requirement when operating an Nd:YAG laser

Room temperature	18–30 °C
Air humidity	20–80%, noncondensing
Air conditioning	Air conditioning recommended
Room temperature 25 °C	Heat output to be dissipated 1.5 kW
Power supply	230 V ± 10% -, 1-phase, 50 Hz/60 Hz, 16A
Space requirement	At least 6 m^2

impermeable roller blind. An efficient warning sign must be installed next to the door of the treatment room, which warns against unauthorized access when the laser is in operation.

In addition to these standard requirements, the distance between the laser device and the wall must be at least 50 cm in direction of the ventilation openings. Ensure that the treatment room is adequately ventilated. Due to the heat discharge of the laser, a ventilation of at least 100 m^3/h is recommended.

12.9 Protective Measures

Cooling

For the use of Nd:YAG lasers for vascular coagulation, they should be equipped with a cooling handpiece which protects the skin surface from thermal damage by means of contact or air cooling.

Safety Goggles

For treatment, all persons in the laser treatment room (including the patient) must wear laser safety glasses that are correct for the wavelength of the respective laser system. The laser safety glasses are marked in accordance with DIN EN 207. The specification for Nd:YAG lasers is shown in Table 12.3.

When treating near the eye, external or internal eye shields must be placed either on the outside or under the eyelids to protect the patient's eyes. Internal eye shields are applied under sterile circumstances to the anesthetized cornea (e.g., 2 drops of oxybuprocaine), using a vacuum gripper after the edges of the metal shields have been coated with sterile ointment (e.g., Bepanthen®-eye ointment).

Table 12.3 Specification of laser safety goggles for long-pulsed Nd:YAG laser radiation

I	1.064 nm	I.6
Laser mode	Wavelength covered by the filter of the safety glasses	Protection level
I = pulsed laser		

12.10 Evaluation of the Nd:YAG Laser in the Clinical Context

Compared to the other photoepilation methods, the Nd:YAG laser achieves excellent and reliable therapeutic results with darker pigment types (Fitzpatrick III–VI).

The Nd:YAG laser can also be regarded as the treatment of choice for dark red, tuberous port-wine stains (Fig. 12.10), hemangioma, and bluish (dark red) telangiectasias. A detailed evaluation of the efficiency is shown in Table 12.1. The noninvasive treatment option for tissues with elevated fat content has already been mentioned.

Facing the range of indications for 1.064 nm wavelength, it is important to distinguish between the long-pulsed Nd:YAG laser and the q-switched solid-state laser. Thus, long-pulsed Nd:YAG lasers cannot break up pigments, so they are not suitable for the removal of tattoos or pigmented lesions.

12.11 Instructions for Learning the Method

Although the use of an Nd:YAG laser is as simple as that of an electrocautery, the risk of side effects is the highest of all laser applications in dermatology.

It is therefore advisable to first perform a hospitation at experienced laser experts in order to avoid beginner's mistakes. In general, the learning curve of an Nd:YAG laser is rather flat, i.e. it takes more than a year until multiple vascular indications can be treated with recurrent success and without side

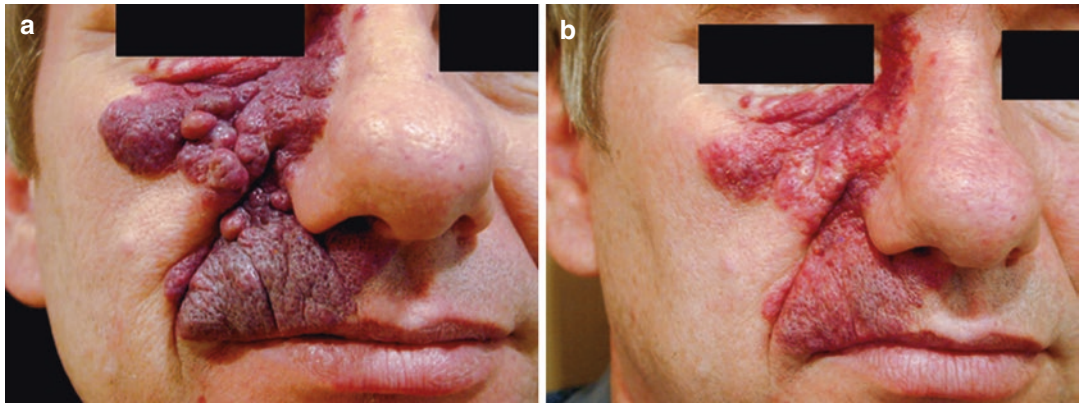

Fig. 12.10 (**a**, **b**) Removal of the tuberous parts of a port-wine stain on the cheek before (**a**) and 4 weeks after 5 treatments with the Nd:YAG laser (**b**), parameters: 5 mm, 8 ms, 80–120 J/cm^2. (From Drosner 2015)

effects. Hospitations can be arranged either via the laser manufacturer and via professional associations or directly with the laser expert. Courses for laser safety are announced in the program of larger dermatological conferences. A specific postgraduate course is offered by the University of Greifswald (www.laserstudium.com).

Conclusion

The Nd:YAG laser is an important all-rounder in the dermatological laser practice and for some indications the treatment method of choice. At the same time, the Nd:YAG laser is also the most dangerous laser in dermatology with regard to its risk for atrophic scars with inadequate handling. Careful parameter selection and cooling of the epidermis parallel to the treatment are important prerequisites for working with this laser without side effects.

Suggested Reading

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