Correspondence:

Dr. S. Michel
Dermatologische Klinik und Poliklinik
der Universität Regensburg
Franz-Josef-Strauß-Allee 11
93053 Regensburg
Germany

Translated from the German Magazin Hautarzt 1997 · 48:462–470 © Springer-Verlag 1997

S. Michel · U. Hohenleutner · W. Bäumler · M. Landthaler · Dermatological Clinic of Regensburg University (Director: Professor M. Landthaler, M.D.)

Dermatological Treatment with the Q-switched Ruby Laser

Indication and Application

Summary

The Q-switched ruby laser (QSR) with its wavelength of 694 nm and a pulse rate in the nanosecond range represents an effective option for the treatment or removal of tattoos and pigmented lesions of the skin. Conceived to operate in accordance with the functional principle of selective photothermolysis, the ruby laser allows for the *targeted* fracturing of pigment particles or pigment-carrying cells in the dermis, and thus enables the scar-free removal of endogenous and exogenous pigment. Common indications for the deployment of the Q-switched ruby laser include amateur, professional and traumatic tattoos as well as permanent makeup and solar lentigos. However, the ruby laser is also well-suited to the treatment of other pigmented skin lesions, such as nevus spilus and cafe-au-lait spots, and to the unproblematic removal of lesions affecting the oral mucosa and the lips (lentigos). As treatment with the Q-switched ruby laser of post-inflammatory hyperpigmentation, chloasma/ melasma and Becker's nevus yields irregular results, the device can be recommended for these conditions only in a restricted sense. In general, treatment of melanocytic skin lesions with the ruby laser is inadvisable. Nevus of Ota and nevus of Ito constitute exceptions in this regard, as there are currently no alternative treatments for these conditions. The non-pigmented cells that are present in almost all melanocytic skin lesions do not absorb ruby laser light, and are thus not susceptible to treatment. The extent to which the partial cell damage associated with ruby laser treatment might pose an increased risk of degeneration is not currently known. Given a proper assessment of the indications, the Q-switched ruby laser represents an outstanding treatment option for the removal of endogenous and exogenous dermal pigment. Given its proven clinical record and its advantages (including minimal side effects that are restricted to transient hyper- and hypopigmentation) when compared to other forms of treatment, the ruby laser enjoys a clear application spectrum in the field of dermatology.

Key words:

Q-switched ruby laser tattoos lentigos

The use of lasers for the treatment of skin disorders has increased considerably in recent years, just as its acceptance has become ever more widespread. That being said, it is important to bear in mind that the various laser systems have specific modes of action and that these specific modes of action must line up with the medical condition in question. While Nd:YAG lasers have a predominantly non-selective and coagulatory thermal effect on tissue and CO2 lasers have a predominantly non-selective and vaporizing thermal effect on tissue, lasers that have a selective mode of action enable the targeted destruction of various skin structures. A selective effect in the treatment of vascular lesions can be achieved to a limited de-

gree with the argon laser and, for instance, with the flash lamp pulsed dye laser (FPDL) [69]. The light of the Q-switched ruby laser (694 nm) penetrates relatively deeply into the skin and is selectively absorbed by dark structures (melanin and exogenously introduced pigments), thereby enabling the treatment of pigmented skin lesions and tattoos.

Argon and CO2 lasers as well as FPDLs have become fixed features of standard dermatological practice and have been described in numerous publications. In light of the continuously increasing interest in lasers for the treatment of pigment alterations and tattoos, a description of the treatment capabilities introduced by these lasers may prove helpful. Based on our own experience with the Q-switched ruby laser and further testimony in the literature, we undertake in what follows to describe the device's range of application in the field of dermatology.

Biophysical Principles

Basic to the understanding of the Q-switched ruby laser's mode of action is the principle of selective photothermolysis. Selective photothermolysis is contingent on three factors:

- The selected wavelength must ensure a sufficiently high degree of laser light absorption in the target structure when compared to surrounding tissue.
- The pulse duration must lie within the range of the target structure's thermal relaxation time so as to ensure that the thermal energy's impact is limited to the target structure and does not affect the surrounding tissue.
- The energy carried by the laser pulse must be sufficient to destroy the target structure.

The fulfillment of these three conditions ensures the selective destruction of certain chromophores in the skin without damaging the surrounding tissue [4, 5].

The so-called Q-switching of the quality-switched ruby laser (QSRL), whose active medium is the ruby crystal, enables high output (100–200 MW) and extremely short pulse times (20–80 ns=10̃9 s) at a wavelength of 694 nm. The red light of the ruby laser penetrates relatively deeply into the skin and is strongly absorbed by more heavily pigmented dermal and epidermal structures, including melanin, melanosomes, melanocytes [20, 42, 54, 58, 69] as well as exogenously introduced color pigments. The extremely rapid heating of the target structure brings about its selective destruction. This is either the result of the extreme temperature gradient that arises within the target structure and/ or the shock wave/ cavitation associated with rapid thermal expansion [8, 42].

Examinations conducted immediately after ruby laser treatment with the use of a light microscope reveal variously sized vacuoles at the locations once occupied by the pigmented structures (see figure 1). Accordingly, epidermal vacuoles are found in the area of the pigmented keratinocytes or nevus cells and dermal vacuoles are found in the area of the pigmented macrophages, nevus cells or tattoo ink. These vacuoles are likely a matter of vapor blisters that correspond to the clinically visible whitening of the skin and that are rapidly reabsorbed. Non-pigmented epidermal tissue is not damaged, with vacuolization a possibility only in the area of the pigmented basal cells.

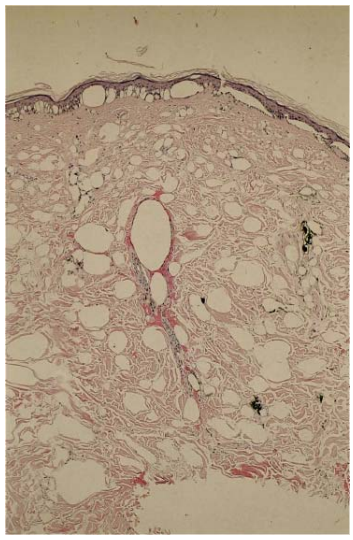

Figure 1: sample biopsy taken immediately after the treatment of a tattoo with the Q-switched ruby laser (8 J /cm2). HE, 100 times

An examination of the treatment zone after one week shows melanin in dermal macrophages that have presumably appeared in the wake of an inflammation reaction for the purpose of degrading the destroyed pigment particles/cells. After a few weeks, the melanin in the epidermis and dermis is histologically reduced. Clinically visible hyper- and hypopigmentation of various manifestations may be in evidence histologically for weeks. Compared to treatment using an argon laser, ruby laser treatment brings about no more than insignificant der-

mal fibrosis [19]. However, what exactly transpires in the tissue after QSRL treatment is still largely unknown, especially with respect to the fate of tattoo ink.

Clinical Application

Given that the pigmented hair itself absorbs a portion of the emitted laser light, it is advisable to shave hairier treatment zones before treatment with the ruby laser. In order to cover the entire area that is to be treated, the 4 mm laser pulses are applied adjacently and in a slightly overlapping (10%) fashion. The patient experiences pain of a piercing or burning nature during the laser treatment. It is not necessary to administer an infiltration anaesthetic to the treatment zone, as has been the case up until now when adhering to other procedures for the removal of tattoos. The application of an anaesthetizing cream (e.g. EMLA® cream, lidocain/prilocain) can be helpful when treating pain-sensitive patients and children, or when the treatment zone involves larger areas of the face. Should bleeding or an epidermal tear occur during treatment, the energy fluence is to be reduced. If the proper energy fluence has been applied, the treated skin surface will appear white immediately after treatment. This “coloration” is of a transient nature and usually disappears within an hour. Erythema and urticarial swelling within the treated area – both of which can persist for a few hours – are common postoperative (up to 24 hours) occurrences associated with energy fluence levels as high as 8 J/cm2. The application of postoperative salves or bandages is not necessary. The patient should be informed that transient blisters or bubbling, which ultimately disappear in the scab-formation process, may continue to appear for days after the operation.

It is absolutely essential to avoid the mechanical manipulation of any scabs that appear. Exposure of the treated area to UV light should also be avoided for a period of several weeks to months. Protecting the lasered skin area with a sunscreen lotion (SPF of at least 16) is advisable. Hyper- and hypopigmentation of various manifestations may occur in the weeks following treatment. These pigmentary changes usually recede after approximately 3-6 months. Scars, persisting pigmentary changes and changes in the texture of the skin do not occur [34]. Most patients report complete healing within an average of 7-14 days. A follow-up visit should take place after 4 weeks at the soonest, as the achieved result cannot be reliably assessed any sooner [35, 73].

The laser device we used (manufactured by the NWL Company) does not permit variations in the beam diameter (4 mm) and in the pulse rate (40 ns). An output of up to 100–200 MW is reached. Energy fluences of 4.5 J/cm2, 5.5 J/cm2 and 8 J/cm2 are applied.

Tattoos

A distinction is made between traumatic or accident-related tattoos and those tattoos that are intentionally applied. This latter category also includes permanent makeup which is applied for the enhancement of eyelid and lip contours. In what follows, we also make a distinction between professionally-applied tattoos and amateur tattoos.

The energy fluences deployed are 4.5 J/cm2, 5.5 J/cm2 and 8 J/cm2. These should be selected in accordance with the location involved and the individual reaction of the patient to the laser treatment. A blanching effect is a sign that the proper energy fluence has been applied. The blanching effect refers to the above-mentioned phenomenon of a momentary whitening of the skin surface immediately after treatment with the ruby laser. That being said, a fluence level of 8 J/cm2 is usually deployed in the treatment of all types of tattoos.

Amateur and Professional Tattoos

The removal of blue/black tattoos numbers among the most common indications for treatment with the Q-switched ruby laser [35, 37, 59, 62, 63, 67, 73, 74]. Our own experience as well as testimony in the literature [63] indicates that at least 4-6 treatment sessions involving the same skin area are necessary for the complete removal of amateur tattoos. Owing to their greater pigment density [46] more treatment sessions are usually required for the complete removal of professionally applied (machine-pierced) tattoos (around 6-10 sessions), although the number of treatment sessions required can vary from case to case. This assessment is supported by numerous studies [62, 63, 67, 74]. We obtained excellent results (< 5% residual pigment) after a sin-

gle ruby laser treatment session in 9% of the 238 amateur tattoos we treated (see figure 2). Good results (75–95% removal) were obtained in 51% of the treated tattoos while satisfactory results (50–75% clearing) were obtained in 33% and unsatisfactory to poor results (<50% lightening) were obtained in 7%. In contrast, we obtained good results (75–95% removal) after a single ruby laser treatment in 10% of the 28 professional tattoos treated (see figure 3). Satisfactory results (50–75% clearing) were obtained in 56% of the tattoos treated and unsatisfactory to poor results (<50% clearing) were obtained in 22%.

The better response in the case of amateur tattoos might be accounted for by the fact that carbon-based inks are often used in amateur tattooing and stable, heavy-metal and organically-based inks are often used for professional tattoos. Older tattoos (10+ years) are more susceptible to ruby laser treatment than younger tattoos. An explanation here would seem to center on the longer exposure of old tattoo ink to phagocytotic degradation and the greater fragility of the older ink.

The responsiveness of the tattoos to Q-switched ruby laser treatment depends largely on the ink or dye used. Blue/black tattoos respond well to ruby laser treatment because they strongly absorb the red laser light. The responsiveness of green tattoo inks varies. Yellow and red tattoos usually do not respond well to the ruby laser and therefore require treatment with other Q-switched lasers (e.g. Q-switched alexandrite laser, Q-switched 1064 Nd:YAG, frequency-doubled (fd) Q-switched 532 Nd:YAG [22, 35, 36, 37, 52, 71]) or conventional forms of pigment removal. Table 1 offers a summary of the responsiveness of various tattoo inks (colors) to the various Q-switched laser systems. The skin color of the patient can also have an impact on the clearing result. Patients with skin types IV–VI, in particular, show a slower response to the ruby laser than fair-skinned patients. The reason for this is that epidermal melanin, located above the tattoo ink, absorbs a significant portion of the laser light.

Traumatic Tattoos

Excellent results were also achieved with the Q-switched ruby laser in the treatment of traumatic tattoos [3, 10, 59]. However, the treatment results here also depend decisively on the “tattooed” pigment. Of 14 patients treated for accident-related tattoos, 7 showed clear responsiveness to the ruby laser over the course of 4-6 treatment sessions, a result echoing that obtained in patients with amateur tattoos. While a lack of a response to the ruby laser was observed in 5 patients, the medical histories of these 5 patients revealed that their injuries were associated with metallic particles (iron) that do not absorb laser light and thus remain inaccessible to the ruby laser. Hyperpigmentation and with it a worsening in the condition of an area of skin used to test the laser response occurred in 2 patients.

Permanent Makeup

The removal of residual, tattoo-like permanent makeup that was originally applied for the enhancement of eyelid and lip contours can also be achieved with the ruby laser [6, 23]. The patients treated at our clinic had undergone lip, eyelid and eyebrow enhancement. The results we obtained with these patients indicate that satisfactory clearing or even complete removal of the makeup can be achieved after 6-8 treatment sessions. However, as in the case of decorative tattoos, the response is dependent on the particular color involved. Furthermore, especially in the case of light or flesh-colored pigments, a color *reversal* (in the direction of black) can occur, a reaction that can largely be accounted for by the oxidation of ferrous salts. While pigments that blackened in this manner can in general be treated with the ruby laser, they do not always respond to the treatment [6, 23].

Advantages

Reports in the literature as well as our own results involving 238 amateur tattoos and 28 professional tattoos indicate that the ruby laser enjoys clear advantages over conventionally used devices and methods for the removal of tattoos, including the argon laser, the CO2 laser, dermabrasion, salabrasion and excision [7, 12, 15, 16, 21, 40, 50, 60, 66]. Ruby laser treatment is a faster method of removal and is less complicated for the patient. Furthermore, it involves virtually no bleeding, it can be carried out without a local anaesthetic, it is associated with far fewer postoperative side effects and its unproblematic application (when compared to the above-mentioned procedures involving tissue removal or tissue destruction) enables the treatment of significantly larger areas of skin.

The treated areas of skin exhibit an unaltered texture and skin tanning and hair growth remain normal. Given adherence to certain prescriptive rules of conduct, such as the securing of protection from UV light and the avoidance of mechanical manipulation, any pigmentary shifting that may have occurred usually disappears entirely after a few months to one year at the latest – at which time the treated area of skin will appear indiscernible from the untreated areas of skin. The side effects associated with other treatment methods [31] (e.g. a lasting pigmentary shift and hypertrophic or keloid scars) have not been observed. Treatment with the ruby laser is also possible in delicate locations, including the eyelids with the use of an eyecup. Furthermore, given the absence of smoke development the risk of infection is also significantly less than, for instance, in the case of treatment with a CO2 laser.

Figure 2: **Black/blue amateur tattoo before ruby laser treatment and nearly complete clearing and discreet hypopigmentation after 4 ruby laser treatments]**

Disadvantages

Transient hypopigmentation in patients with darker skin types or hyperpigmentation, especially after UV exposure, are not uncommon occurrences after ruby laser treatment. Patients with darker

skin types tend to exhibit hypopigmentation. In most cases, however, this side effect recedes after 4-6 months. We ascertained transient hypo- or hyperpigmentation in 23% of the patients we treated.

In addition to the inadequate response of some tattoo colors to treatment, the possible blackening of relatively light "earth" or "flesh" tones (i.e. ferrous-based inks) warrants mention, especially given the fact that the blackening can prove irreversible if it does not respond to renewed laser therapy (oxidation process [6, 23]).

Although it has often been described in the literature, the triggering of skin lesions by tattoos (i.e. by the inks used) is rare. The process by which ink is introduced into the dermis can cause skin irritation and lead to the onset of skin disorders (psoriasis vulgaris, lichen ruber planus) [30, 81]. In addition to this, pseudolymphoma and granulomatosis of the foreign-body or sarcoidosis type can occur in tattooed areas of skin. These can be attributed to the ink particles situated in the skin [30, 51, 81]. Allergic and photoallergic reactions to tattoo ink components (heavy metals such as mercury and chromate) have been de-

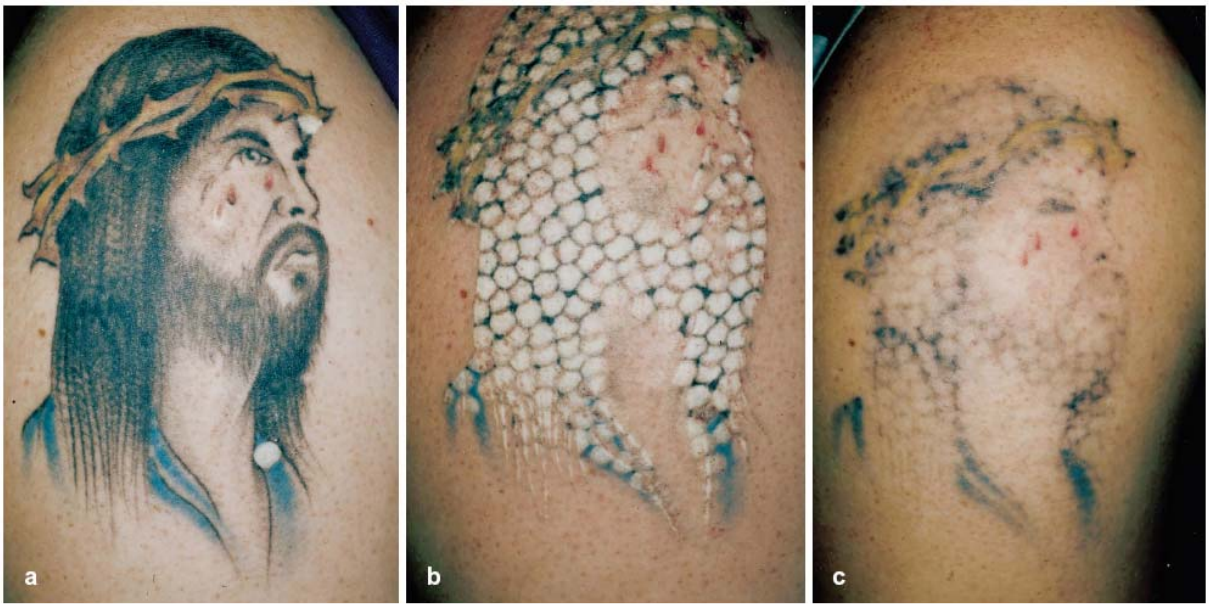

Figure 3: Status of a multicolored amateur tattoo immediately after sample treatment in 3 areas of different color, status immediately after the first large-surface treatment and status 4 weeks after the first treatment session. Inadequate response is seen in the light blue, red and yellow areas.

Table 1

The response of various tattoo inks to various Q-switched laser systems.
(cf. Kilmer and Alster [39])

Tattoo ink	Ruby (694 nm)	Alexandrite (755 nm)	Nd:YAG (1064 nm)	fd Nd:YAG (532 nm)	PLDL (510 nm)
Blue/black	+++	+++	+++	–	–
Green	++	++	+/–	–	–
Red	–	–	–	+	+
Orange	–	–	–	+	+

PLDL = pigmented lesion dye laser; fd Nd:YAG = frequency-doubled Neodymium:YAG laser]

scribed in the literature [48, 78, 81]. The most commonly observed allergic reactions are those associated with the sulfur sulfides in red inks [1, 2, 43, 49, 56, 65]. Other allergic reactions have been traced to blue cobalt-containing ink [13], green chrome-containing ink [47] and yellow cadmium-containing ink [14]. Theoretically, the triggering of such inflammatory and allergic reactions to ink components by QRSL treatment is possible, seeing as how the inks are chemically and/or mechanically altered via the selective photothermolysis in a manner that is not currently understood. Initial cases of allergic reactions (type I) following ruby laser treatment have already been observed [11].

The considerably larger expense associated with ruby laser treatment when compared to the above-mentioned alternative treatment procedures is to be regarded as a major disadvantage.

Pigmented Lesions of the Skin

As has already been mentioned, melanin also absorbs ruby laser light. For this reason, pigmented skin lesions of the dermis and epidermis can be cleared or removed [27, 75].

Depending on the location of the skin lesion and the pa-

tient-specific response to treatment (as determined by the "blanching" effect that occurs immediately after the sample treatment), energy fluences between 4.5 J/cm2 and 8 J/cm2 are applied. The term "blanching" refers to the above-described phenomenon involving a momentary whitening of the skin surface immediately after ruby laser treatment. The blanching response indicates that the proper fluence level has been applied.

Lentigo Solaris, Lentigo Simplex, Lentigo Simplex Labialis, Lentigo of the Penis/Vulva

Excellent results have been observed in the treatment of solar lentigos (age spots) appearing on the face and the backs of the hands. A cosmetically satisfactory clearing or complete removal of the cosmetically troubling skin lesions can be achieved after 1-2 treatments (see figure 4) [24, 27, 29, 44, 55, 75]. We treated a total of 70 patients with solar lentigos. Of these patients, 26.6% showed excellent clearing (□95%) by the first post-treatment visit, 63.3% showed good clearing (75-95%) and 10% showed satisfactory clearing (50-75%). Similarly excellent cosmetic results (that are also corroborated by our own unpublished observations) have been reported in the treatment of labial lentigos [9, 32] (also in the context of Peutz-Jegher's syndrome affecting the lips and oral mucosa [57]) and in the treatment of superficial pigmented lesions of the skin (ephelides) [33, 55]. Here, too, excellent skin clearing can be achieved after 1-2 treatment session. Delaney reports on the successful treatment of penile melanosis with the ruby laser in combination with the topical application of an anaesthetizing cream [18].

Nevus Spilus, Café-au-lait Spots

The satisfactory clearing of skin lesions can be achieved in the treatment of nevus spilus and café-au-lait spots after around 4-6 ruby laser sessions. While our own results drawn from the treatment of 10 patients indicate that the nevi spili are usually not completely removed, they can often be satisfactorily cleared, with the more darkly pigmented areas of nevus spilus responding significantly better to the ruby laser. We also observed cases of total resistance to ruby laser treatment. Clinical worsening in the form of hyperpigmentation occurred in none of our patients. However, in one of the ten patients pigmentation relapse occurred after a certain latency period, a result also reported on by Goldberg in 1993 [27]. We were not able to confirm the outstanding skin clearing results after ruby laser treatment for nevi spili that were reported by Nelson and Applebaum [53, 55].

Skin clearing can also be achieved in the treatment of café-au-lait spots. Pronounced skin clearing (although seldom the complete removal of skin lesions) was reached after an average of 4-6 sessions with the ruby laser in 14 patients with café-au-lait spots. We also observed a varying degree of responsiveness at different locations of the same skin lesion. Kilmer et al. report comparable results for café-au-lait spots when treated with pulsed lasers [38]. We were able to help a few patients who exhibited pigmentation relapse with so-called interval therapy. Immediately after the clearing of the skin lesions and before the appearance of repigmentation, the same areas were re-exposed to the ruby laser in order to thereby reach and destroy the deeper-lying, pigmented structures (e.g. hair follicles) that can, based on our own unpublished data, be the source of pigmentary relapse.

Postinflammatory Hyperpigmentation, Chloasma, Melasma

Clinical data indicate that results are very inconsistent when it comes to the treatment of other types of pigmented skin lesions for which one might reasonably expect skin clearing. Our own experience as well as data published in the literature show that, for instance, postinflammatory hyperpigmentation, chloasma and melasma all represent poor indications for ruby laser treatment, given that around 33% of such cases exhibited no clinical improvement as a result of treatment and another 33% exhibited clinical worsening in the form of hyperpigmentation [41, 76].

Discussions of the cause of the varying responsiveness to the ruby laser exhibited by the above-mentioned skin lesions center on the extremely variable position of the pigment within the dermis [38] and the tendency of these patients to react to minor trauma with hyperpigmentation. It may be that melanin production is triggered by the

treatment. Collins reports on 4 patients with minocycline-induced hyperpigmentation (following acne treatment) whose aesthetically unsettling skin lesions were completely removed via ruby laser treatment [17].

Becker's nevus patients contrast with those reported by Nelson and Applebaum. Their results showed long-term skin clearing without pigmentary relapse or other side effects such as hypertrophic scars, atrophic skin sinking and skin texture alterations [55]. Raulin

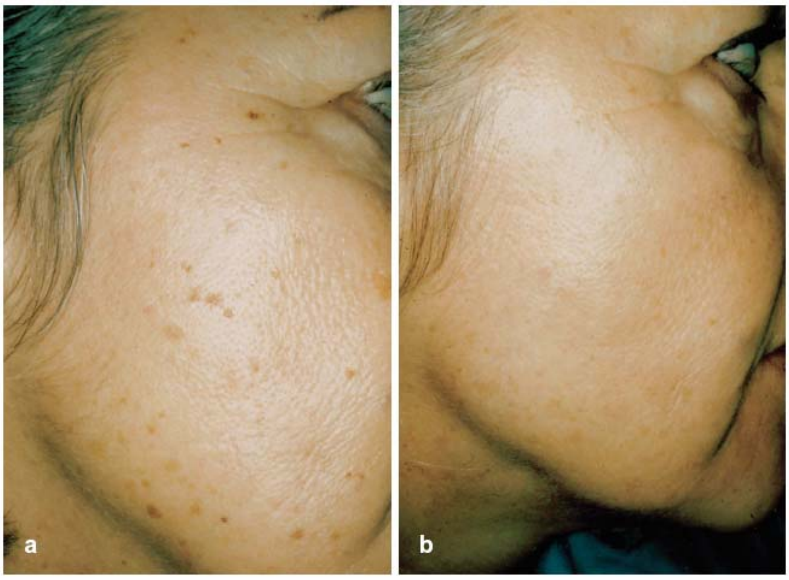

Figure 4: **solar lentigos and flat seborrheic verruca before ruby laser treatment and virtual total clearing after a single session with the ruby laser**

Becker's Nevi

Comparable results were obtained in the treatment of Becker's nevi. Clinical worsening due to hyperpigmentation and the repigmentation of areas of skin that had already been lightened via treatment were frequently observed in hairier areas. In general, the treatment results for these pigmented skin lesions are scarcely predictable and side effects such as hypo and hyperpigmentation are not uncommon. Our investigations showed clinical improvements after ruby laser treatment in 2 of 9 patients with Becker's nevus, while 5 patients showed unsatisfactory to negligible improvement and 2 patients showed clinical worsening. These results in also reports on the successful treatment of the pigmented portions of a Becker's nevus with the Q-switched ruby laser [60]. One should be able to subsequently treat the hair growth of the skin lesion using non-coherent light with a continuous wave spectrum (Photoderm VL) [60], via conventional epilation or the use of the ruby laser in non-Q-switched mode.

Melanocytic Nevi

In approaching melanocytic skin lesions, it is important to bear in mind that sufficiently strongly pigmented cells are the only ones that can be destroyed because they alone absorb sufficient laser light. The effect on less strongly pigmented (or nonpigmented) melanocytic cells, which usually predominate in these types of skin lesions, is not yet understood. Histological investigations of nevocellular nevi following ruby laser treatment indicate that while the nevus cells are reduced, they remain present (e.g. at a deeper level) in the vast majority of patients [28, 68, 79]. Whether these cells remain completely undamaged, only partially damaged or whether cellular degeneration is introduced after a latency period of a few years via a laser-related increase in the number of pathologically altered cells is currently unknown.

In light of this, it is our opinion that melanocytic skin lesions, especially nevocellular nevi, should not, as a rule, be treated with the Q-switched ruby laser, especially in light of the fact that other satisfactory treatment procedures are available. Individual cases of treatment involving congenital melanocytic nevi have been described in the literature [28, 79]. Treatment with a ruby laser is only to be considered in the case of melanocytic nevi that are very cosmetically disfiguring, and for which alternative treatments achieve no more than unsatisfactory results. Furthermore, full treatment with the ruby laser should be made contingent on the results of response testing. Reservations with respect to the treatment of melanocytic nevi with the ruby laser have also been expressed the United States, with most laser users rejecting the method altogether (this at least has been suggested by Professor Tan of Boston in the context of a personal exchange [38]). The degeneration potential of the

remaining sublethally damaged cells is currently not known, and the recurrence that is unavoidable on account of the remaining nevus cells (as is known in the case of recurrent nevi) are difficult to judge in histological terms. An exact dermatological diagnosis (if appropriate, including dermatoscopic and/or bioptic verification) should be carried out before each and every treatment of pigmented, melanin-related skin lesions with the ruby laser. Furthermore, it also warrants bearing in mind that clinical-diagnostic reliability in the case of malignant melanoma is only roughly 80% when carried out by experienced practitioners [64, 70].

Nevus of Ota

Given that no alternative is available, the treatment of nevus of Ota represents an exception. That being said, the fact that nevus cells remain at a deep level [25, 26, 53] means that one would have to expect recurrence. After preliminary bioptic verification of the diagnoses, good treatment results were obtained after around 4-6 treatment sessions at fluence levels of 8–10 J/cm2 [25, 26, 45, 77, 80]. Goldberg and Lowe have even reported excellent results after 3-4 treatment sessions [26, 45].

Epilation for Hypertrichosis

In non-Q-switched mode, the ruby laser (694 nm wavelength, 0.5 ms pulse duration) has also been tested as a device for epilation in patients with hypertrichosis. The initial results are little encouraging. Up to 30% less hair grows after one or more than one treatment sessions. However, the current absence of reliable data prevents any conclusive assessment with respect to the duration of the hair loss.

In summary, the Q-switched ruby laser is well-suited to the treatment of solar lentigos and blue/black amateur and professional tattoos. Depending on the nature of the pigment involved, tattoos of other colors, accident-related traumatic tattoos and permanent makeup respond well to treatment. Provided that response testing is positive, a full course of treatment can be regarded as justifiable for the following indications: nevus spilus, café-au-lait spots, postinflammatory hyperpigmentation, chloasma, melasma and Becker's nevus. Clinical worsening may occur in the latter 3 of these indications. Except in individual cases, treatment of nevocellular nevi with the ruby laser cannot be recommended, with nevus of Ota/Ito and the non-cell-rich blue nevus constituting exceptions so long as no other therapeutic alternatives are available.

Owing to the outstanding treatment results (including the minimal incidence of side effects) that have been achieved with the Q-switched ruby laser when used for the proper indication, it represents an excellent treatment option. That being said, safe and successful treatment with the Q-switched ruby laser presupposes the fulfillment of the following conditions:

- Knowledge of the ruby laser's mode of action, and the resulting realistic assessment of indications and contraindications
- Provision to the patient of a precise explanation of expected results and any possible side effects
- Provision of emergency equipment and the presence of physicians or relevantly trained medical staff (given that the occurrence of allergic reactions during treatment cannot be ruled out)
- An exact dermatological diagnosis, especially in the case of pigmented skin lesions (if appropriate including dermatoscopic and bioptic diagnosis verification)

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