Tattoo removal

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INTRODUCTION

Tattoo removal is an increasingly common office procedure often performed by dermatologists with special training in tattoo removal. A variety of procedures have been used to remove tattoos, such as laser therapy, surgical excision, and dermabrasion. Quality-switched (Q-switched, QS) lasers are the standard of care for tattoo removal based upon demonstrated efficacy and safety and an extensive history of use for this indication. QS laser treatment can result in good cosmetic outcomes and complete or near-complete removal of many unwanted tattoos.

The approach to tattoo removal will be reviewed here. The epidemiology of tattoos, tattoo placement process, and health risks of tattooing are reviewed separately. (See "Tattooing in adolescents and young adults".)

TATTOO PRINCIPLES

A tattoo is visible and permanent pigmentation of the skin secondary to the deliberate or accidental deposition of exogenous pigment within the dermis. There are five major subtypes of tattoo [1]:

- **Professional tattoos** – Professional tattoos are decorative tattoos placed by professional tattoo artists and are typically placed with a vibrating needle.

Pigment is deposited more deeply and extensively in the dermis than most amateur tattoos, which can make professional tattoos more difficult to remove.

- **Amateur tattoos** – Amateur tattoos are decorative tattoos performed by nonprofessionals. Amateur tattoos are often placed by hand with a needle or other improvised devices. Amateur tattoos are most often black and may contain ingredients such as charcoal, soot, or pen ink.
- **Traumatic tattoos** – Traumatic tattoos result from the entry of pigmented substances, such as gunpowder or road residue (eg, dirt, asphalt, gravel), into the skin in sites of cutaneous injury (picture 1). The pigment remains following re-epithelialization, causing permanent discoloration of the skin.
- **Medical tattoos** – Tattoos may be placed following reconstructive surgery (eg, areolar tattoo in breast construction) or to facilitate patient positioning for radiation therapy.
- **Cosmetic tattoos** – Cosmetic tattoos are tattoos placed for the purpose of permanent makeup. The lips and eyebrows are common sites.

Tattoo pigments are composed of a wide variety of ingredients. Common ingredients used to create specific colors in professional tattoos include:

- Black: carbon and iron oxide
- Blue: cobaltic aluminate
- Green: chrome oxide
- Red: mercury sulfide or cadmium selenide
- Yellow: cadmium sulfide or ochre
- White: titanium dioxide and zinc oxide

Tattoo pigment particles deposited in the skin are subsequently taken up by phagocytic cells. Histopathologic examination will reveal pigment particles within large phagosomes in the cytoplasm of epidermal keratinocytes and dermal phagocytic cells (ie, fibroblasts, macrophages, or mast cells).

TREATMENT PRINCIPLES

Although most individuals with decorative tattoos are satisfied with their tattoos, a desire to remove tattoos is not uncommon [2,3]. Among 120 patients who reported having a tattoo in an American telephone survey, 20 (17 percent) had considered tattoo removal [2]. Reasons for desiring removal may include embarrassment, a negative impact on body image, occupational concerns or requirements, concern for stigmatization, and life status changes [3].

In the past, methods for tattoo removal were limited to excisional and destructive procedures (eg, surgical excision, dermabrasion, traditional ablative lasers). The discovery of the theory of selective photothermolysis, which describes how light can be manipulated to achieve a desired clinical effect while limiting collateral tissue damage, has contributed to advances in laser therapy for tattoos. (See 'Surgical excision and destructive therapies' below and "Principles of laser and intense pulsed light for cutaneous lesions", section on 'Selective photothermolysis'.)

The theory of selective photothermolysis includes the following principles:

- The wavelength of light delivered should be preferentially absorbed by the target molecule (also known as a chromophore).
- Light must be delivered within a period of time that limits damage to adjacent tissue.
- The light energy transferred to the target chromophore must be sufficient to exert the desired therapeutic effect while minimizing damage to adjacent tissue.

In tattoo removal, the target chromophore is the deposited pigment. The laser selected should emit light in a wavelength that is preferentially absorbed by the targeted pigment, should have a pulse duration that is sufficiently short to heat pigment particles while minimizing damage to adjacent tissues, and should be utilized at an energy (fluence) setting that is sufficient to destroy tattoo pigment.

Tattoo pigment particles of different colors preferentially absorb different wavelengths of light; therefore, attention to the colors within a tattoo is critical, and more than one laser is often required to remove a multicolored tattoo. Laser wavelengths preferentially absorbed by specific tattoo pigments are reviewed in a table (table 1). (See "Principles of laser and intense pulsed light for cutaneous lesions", section on 'Wavelength'.)

The selection of the correct pulse duration is based upon knowledge of the thermal relaxation time of tattoo particles (the time required for a target to lose heat). Heating the target for periods shorter than the thermal relaxation time prevents damage to surrounding tissue. Tattoo pigment particles are small and have a short thermal relaxation time (<10 ns) compared with larger structures. Thus, lasers capable of emitting very short pulses, such as quality-switched (Q-switched, QS) lasers, which emit nanosecond pulses, are the primary devices utilized for tattoo removal. (See "Principles of laser and intense pulsed light for cutaneous lesions", section on 'Pulse duration'.)

FIRST-LINE TREATMENT

Quality-switched (Q-switched, QS) lasers are the preferred first-line treatment for most tattoos. Tattoos exhibiting allergic reactions are an exception because exacerbation of the allergic reaction may occur after laser treatment. (See 'Patient evaluation' below.)

Quality-switched lasers — Quality-switched (Q-switched, QS) lasers have been the standard of care for tattoo removal for over two decades [4]. The range of laser wavelengths available in QS devices and the short pulse durations of these lasers allow for effective treatment of tattoos with low risk for scarring.

Mechanism and efficacy — QS lasers generate short nanosecond bursts of laser light that break apart tattoo pigment in the dermis. QS lasers have an electro-optical switch within the laser cavity that facilitates the release of all of the laser energy stored in the laser cavity in a single brief, powerful pulse. This results in very rapid heating and resultant shattering of tattoo particles.

Shattered tattoo pigment fragments either remain in the dermis or are removed by the lymphatic system. Due to tissue optics, the unaided human eye is unable to see very small pigment fragments in the skin. Tattoo fragments that are removed lymphatically are sequestered in lymph nodes.

QS lasers are available in a variety of wavelengths and are selected based upon tattoo color(s) (table 1). Efficacy of QS 532 nm neodymium-doped:yttrium aluminum garnet (Nd:YAG) [5], QS 694 nm ruby [4], QS 755 nm alexandrite [6], and QS 1064 nm Nd:YAG lasers [5,7] for tattoo removal is documented in uncontrolled and comparative studies. As an example, in a series of 397 patients treated with a QS 1064 nm Nd:YAG laser, QS 532 nm Nd:YAG laser, and/or a QS 755 nm alexandrite laser according to tattoo color with a minimum treatment interval of six weeks, successful removal of the tattoo occurred in 47.2 percent (95% CI, 41.8-52.5 percent) of patients after 10 sessions and 74.8 percent (95% CI, 68.9-80.7 percent) of patients after 15 sessions [8]. Amateur tattoos generally are more responsive to QS laser treatment than professional tattoos [4,5].

Pretreatment measures — A careful clinical evaluation and patient education are essential prior to treatment.

Patient evaluation — Patients desiring tattoo removal should be carefully assessed to aid in the selection of an appropriate laser and to minimize the risk for complications. Important factors to assess include tattoo color(s), patient skin color, tattoo placement history, and history of tattoo reactions:

- **Tattoo color(s)** – The colors within a tattoo determine the most appropriate QS laser(s) based upon the theory of selective photothermolysis (table 1). More than one laser is usually necessary for optimal treatment of tattoos with multiple colors. In general, yellow and orange pigments are the most difficult to remove, whereas blue and black pigments tend to be the easiest to remove.

  Tattoos containing iron oxide or titanium dioxide (typically tan, brown, or white tattoos or cosmetic tattoos) can exhibit paradoxical darkening immediately after treatment secondary to chemical reduction of ferric oxide or titanium dioxide. Tattoos that demonstrate this finding may be best treated with ablative laser resurfacing with a carbon dioxide or erbium:yttrium aluminum garnet (Er:YAG) laser [9]. (See 'Surgical excision and destructive therapies' below and "Ablative laser resurfacing for skin rejuvenation".)

- **Skin color** – Dyspigmentation (hypopigmentation or hyperpigmentation) is a potential consequence of laser therapy that is most likely to occur in patients with dark skin (eg, Fitzpatrick skin phototypes V and VI (table 2)). A "ghosting" phenomenon, the development of a hypopigmented outline of the tattoo at the site of the tattoo removal, can occur in patients with highly pigmented skin. The QS 1064 nm Nd:YAG laser has been associated with reduced risk for pigmentary changes compared with other QS lasers and is the laser of choice for tattoo removal in patients with dark skin [10].

- **Placement history** – Professional tattoos are often more challenging to treat than amateur tattoos given that pigment is usually placed deeper and more extensively in the dermis. More treatment sessions and higher fluence settings may be necessary for the removal of professional tattoos.

  For patients with traumatic tattoos, knowledge of the composition of deposited pigment particles may be important. The occasional occurrence of pox-like scarring after QS laser treatment of traumatic tattoos containing combustible materials such as gunpowder or firework debris has been reported [11,12]. The mechanism of this adverse event is postulated to involve the induction of microexplosions within tissue [12]. Treatment of a small area (ie, test spot) prior to treatment of larger areas can minimize disfigurement in patients who experience this side effect.

- **History of tattoo reactions** – Local or systemic allergic reactions to tattoo pigment can occur following laser treatment [13]. Patients with a history of local or systemic allergic reactions after placement of tattoos may experience recurrences with laser treatment.

  QS laser treatment of tattoos with allergic reactions generally is not recommended. When such reactions cannot be managed with medical interventions, surgical excision of the affected area(s) of the tattoo is the preferred intervention. Fractionated laser therapy has also been suggested. (See 'Fractionated lasers' below.)

Assessment of other factors may aid in predicting the response to treatment. A prospective cohort study of 352 patients treated with a QS 532/1064 nm Nd:YAG laser and a QS 755 nm alexandrite laser based upon tattoo colors found reduced clinical responses in association with smoking, colors other than black and red, tattoo size >30 cm^2, tattoos older than 36 months, high color density, location on the feet or the legs, and treatment interval shorter than eight weeks [8].

Patient counseling — Patients should be thoroughly counseled about risks and expectations for treatment. In particular, we inform patients that although QS lasers are effective, complete removal is not guaranteed and multiple treatments are typically required. Often, eight or more treatment sessions are required to achieve maximum improvement. Potential side effects (eg, blistering, dyspigmentation, scarring) should also be reviewed. It is particularly important to discuss risk for scarring with patients who have a history of hypertrophic or keloidal scars since scars are more likely to be disfiguring in these patients.

Treatment of tanned skin is generally not recommended to minimize risk for complications (eg, dyspigmentation, blistering, scarring) related to the absorption of laser light by melanin in the epidermis. Patients should protect the tattoo area from sun exposure with sunscreens and sun-protective clothing prior to treatment and existing tans should fade prior to treatment.

Prophylactic antibiotic or antiviral therapy generally is not necessary; however, prophylactic therapy for the prevention of herpes simplex virus reactivation is reasonable for patients receiving treatment of perioral tattoos. For these patients, antiviral therapy (eg, 500 mg of valacyclovir or famciclovir given twice daily or 400 mg of acyclovir given twice daily) can begin one day prior to treatment and is continued until healing.

Photography — Photographs are helpful for assessing the response to treatment. Photographs are typically taken prior to initial and subsequent treatment sessions.

Administration — Treatment of a test spot (a small inconspicuous area of the tattoo) is suggested prior to treatment of the entire tattoo. Performance of a test spot can identify unexpected adverse effects, such as paradoxical darkening or scarring.

Skin should be thoroughly cleansed and dry prior to the start of treatment. Anesthesia is usually necessary; topical or intralesional anaesthesia or regional blocks are commonly used.

Once the appropriate laser wavelength is selected based upon tattoo color, the clinician should select the most appropriate fluence (energy) setting. For the first few treatment sessions, relatively low fluence settings should be used to minimize adverse effects. The lowest fluence setting sufficient to induce slight whitening of the tattooed skin immediately after the laser pulse is delivered (immediate whitening reaction) should be used.

A single laser pass is typically performed during each treatment session, though multiple pass protocols have been utilized by some authors to reduce the number of required treatment sessions. Multiple pass protocols involve subsequent laser passes performed after the resolution of the immediate whitening reaction. This has been accomplished through a waiting period of 20 minutes between laser passes (R20 method) or facilitated through use of topical perfluorodecalin to resolve immediate whitening reactions more quickly (P0 method) [14-16]. However, these multipass protocols have not gained favor in clinical practice due to the time-consuming nature of multiple same-day treatments and unclear superiority to standard treatment.

Additional treatment sessions are usually separated by four to six weeks. Subsequent treatments may need higher laser energy settings to remove residual tattoo pigment. In general, QS laser therapy is not considered ineffective until the fluence dose has been optimized and patients have failed to achieve an adequate response to multiple treatments (eg, >10 treatments).

Post-treatment care — Our preferred post-treatment care of the laser site consists of daily application of a bland, occlusive ointment such as petrolatum to maintain wound moisture. Moisture promotes wound healing, and application should continue until the treatment site is fully healed. Crusting and scabbing are normal occurrences that typically persist for one to two weeks after treatment [17]. Some patients find cool packs helpful for minimizing discomfort after treatment.

Patients should protect treated skin from sun exposure through use of sun-protective clothing and sunscreen to minimize risk of postinflammatory hyperpigmentation. Strict sun protection should be continued for at least several weeks after treatment.

Adverse effects — The most common adverse effects of QS laser treatment include blister formation, bleeding, infection (if the skin barrier is compromised), and scarring. Scarring typically occurs if the laser energy settings are too high or due to abnormal healing after treatment. Infrequent adverse events include local or widespread allergic reactions [13,18,19].

Alternative therapy — Picosecond lasers are an additional treatment option for tattoo removal. However, picosecond laser therapy has not been proven superior to quality-switched (Q-switched, QS) laser therapy, and QS lasers remain the gold standard for tattoo removal.

Picosecond lasers — Picosecond lasers have pulse durations in the picosecond range. It is proposed that the very short pulse duration facilitates treatment of small targets with short thermal relaxation times, such as tattoo particles. Picosecond laser treatments cause significant photomechanical effects and are thought to lead to mechanical breakup of pigment particles with minimal collateral tissue heating [20,21]. Compared with QS lasers, lower fluence settings are required for tattoo removal.

Whether picosecond lasers are more effective than QS lasers is uncertain. Although successful treatment of black and colored tattoos with picosecond alexandrite and neodymium-doped:yttrium aluminum garnet (Nd:YAG) lasers is documented in uncontrolled studies [22-26], data from randomized trials conflict. A single-blind randomized trial in which 30 black professional tattoos in 21 patients were treated with a picosecond 1064 nm Nd:YAG laser (fluence 0.2 to 12.5 J/cm^2, spot size 3 to 8 mm) on one-half of a tattoo and a QS 1064 nm Nd:YAG laser (fluence 2 to 12 J/cm^2, spot size 2 to 10 mm) on the contralateral half did not find a significant difference in efficacy after two treatments [27]. A separate single-blind randomized trial in which 49 patients with tattoos (primarily professional and black or blue tattoos) received treatment with one of two picosecond 1064/532 nm lasers (fluence ranges 2 to 8.4 and 2 to 5.5 J/cm^2) on one-half of a tattoo and treatment with a QS 1064/532 nm nanosecond laser (fluence 2 to 8.4 J/cm^2) on the other half found the picosecond laser more effective for reducing at least 75 percent of the color intensity of the tattoos (33 versus 14 percent achieved this endpoint) [28]. Both trials found picosecond laser treatments less painful.

OTHER THERAPIES

Less common methods for tattoo removal include surgical excision, destructive therapies, and fractionated ablative lasers. Topical imiquimod does not appear to be a useful therapy.

Surgical excision and destructive therapies — The use of surgical excision and destructive therapies such as traditional ablative lasers and dermabrasion declined significantly following the discovery of the efficacy and safety of quality-switched (Q-switched, QS) laser therapy. The major disadvantage of these therapies is risk for scarring.

Patients who are poor candidates for QS laser therapy (eg, patients with allergic tattoo reactions [surgical excision preferred] or paradoxical pigment darkening in response to QS laser treatment) and patients who lack access to QS laser therapy can be successfully treated with these modalities [29,30]. In addition, punch biopsy excision is an effective method for removing very small tattoos, such as iatrogenic radiation tattoos; in a trial in which two radiation tattoos in 10 patients were randomly assigned to either punch biopsy excision or three QS yttrium aluminum garnet (YAG) laser treatments, a 75 to 100 percent reduction in tattoo appearance was achieved for all tattoos except one tattoo in the laser group [31]. However, scarring and hypopigmentation were more frequent in the punch biopsy excision group, and most patients preferred laser therapy.

The protocol for traditional ablative laser therapy mimics the protocols utilized for skin rejuvenation. Traditional ablative laser therapy is reviewed in detail separately. (See "Ablative laser resurfacing for skin rejuvenation", section on 'Traditional ablative lasers'.)

Dermabrasion involves superficial abrasion of the skin with an abrading device. Adequate depth of abrasion is indicated by brightening of the tattoo color and a glistening aspect to the skin surface. Several sessions may be required for tattoo removal [29].

Fractionated lasers — Fractionated ablative lasers function by pixelated vaporization of skin tissue, leaving primarily unaffected skin in between zones of ablation to serve as reservoirs for healing (figure 1). The proposed mechanisms for tattoo removal include physical removal of a portion of the tattoo, transepidermal elimination of pigment through the microscopic channels created by the laser, and additional removal of tattoo pigment during the wound-healing process [32]. Transepidermal elimination of tattoo pigment following nonablative and ablative fractional laser therapy has been demonstrated in animal studies [33,34]. (See "Principles of laser and intense pulsed light for cutaneous lesions", section on 'Fractionated lasers'.)

Data on the clinical use of ablative fractionated lasers for tattoo removal are limited. Better responses to combination treatment with a fractioned carbon dioxide laser and QS ruby laser compared with the QS laser alone is documented in case reports [35]. Significant removal of tattoo pigment and improvement of symptoms of tattoo allergy after treatment with a 2940 nm erbium:yttrium aluminum garnet (Er:YAG) fractionated laser alone or in combination with a QS neodymium-doped:yttrium aluminum garnet (Nd:YAG) laser has also been described in individual patients [32]; however, a generalized hypersensitivity reaction has also occurred after such treatment [36].

Combination treatment with a picosecond 755 nm alexandrite laser and fractionated carbon dioxide laser may reduce risk for bulla formation, a common side effect of treatment with the picosecond 755 nm alexandrite laser. In a retrospective study, 26 of 81 patients (32 percent) treated with the picosecond 755 nm alexandrite laser alone developed blistering compared with none of 20 patients treated with both modalities [37].

Imiquimod — Topical imiquimod was proposed as a method to augment the efficacy of laser tattoo treatment based upon observed benefit for tattoo removal in an animal model [38]. However, in a small, randomized trial, the addition of imiquimod to QS laser therapy did not increase treatment efficacy [39].

SUMMARY AND RECOMMENDATIONS

- Tattoos are visible and permanent deposits of exogenous pigment in the skin. Although most individuals with decorative tattoos are satisfied with their tattoos, a subset desire removal. (See 'Tattoo principles' above and 'Treatment principles' above.)

- Lasers are the primary treatment modality for tattoo removal. Discovery of the theory of selective photothermolysis, which describes how light can be manipulated to achieve a desired clinical effect while limiting collateral tissue damage, has facilitated effective and safe laser therapy for tattoos. (See 'Treatment principles' above.)

- Tattoo pigment particles have short thermal relaxation times; therefore, lasers with short pulse durations, such as quality-switched (Q-switched, QS) lasers, are necessary to minimize damage to adjacent tissues. We suggest QS laser therapy as the first-line intervention for tattoo removal (**Grade 2B**). QS lasers have a long history of use for tattoo removal and have demonstrated efficacy and safety for this indication. QS laser therapy may exacerbate tattoo allergic reactions and is not advised for tattoos with allergic reactions. (See 'Quality-switched lasers' above.)

- Candidates for QS laser therapy should be carefully evaluated to assist with selection of the appropriate laser and minimize side effects. QS lasers are available in a variety of wavelengths. Selection of the appropriate laser wavelength is guided by the colors in the tattoo. Treatment of a test spot is prudent prior to full treatment of a tattoo. (See 'Pretreatment measures' above.)

- Patients should be thoroughly informed of the risks of QS laser therapy prior to treatment. Patients should also be informed that multiple treatment sessions are typically necessary for optimal results and that complete removal is not guaranteed. (See 'Patient counseling' above.)
- Picosecond laser therapy is an alternative treatment modality that appears effective for tattoo removal, though relative efficacy to QS lasers is unclear. (See 'Alternative therapy' above.)
- Limited data suggest that fractionated lasers may also be useful for tattoo removal. Further study is necessary to clarify the role of picosecond lasers and fractionated lasers in the treatment algorithm for tattoo removal. (See 'Picosecond lasers' above and 'Fractionated lasers' above.)

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