

REVIEW ARTICLE

Tattoo removal by non-professionals – medical and forensic considerations

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Abstract

Tattoos are common phenomena in the western world and the demand for their removal has become widespread in the recent years. The introduction of quality-switched lasers has provided an effective removal method that is increasingly being exploited by tattoo studios themselves. Dermatologists, however, are frequently confronted with complications and side effects of tattoo removals that were performed by non-professionals. The objective of this study is to assess potential risks and pitfalls of laser tattoo removal when performed by medical laymen. The methods followed are systematic and evidence-based review of the literature. Four major problem areas were identified: rare but potentially severe allergic or toxic effects of decomposition products of the tattoo pigments; bodily harm caused by out-of-specification usage of the laser devices; malignant disease that is obscured within the area of a tattoo and requires meticulous dermatological diagnosis; and insufficient pre-operative consultation of patients about the risks, side effects and realistic expectations on the therapeutic outcome. We came to a conclusion that tattoo laser removal by medical laymen is unacceptable from the point of view of patient safety and the laws need to ban this practice swiftly.

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Keywords

adverse effects, equipment safety, laser surgery, medical staff, patient care team, privileges, tattooing

Conflict of interest

C. Raulin is affiliated with a dermatological surgery that provides laser tattoo removal. G. Krieger is a former legal advisor of the German Dermatologists Association [Berufsverband Deutscher Dermatologen (BVDD)].

Introduction

Dermatologists in some developed countries are being increasingly confronted with sequelae and/or side effects of laser tattoo removal performed by non-physicians – mainly tattooists themselves. Indeed, laser tattoo removal is becoming more and more aggressively advertised by franchise companies in several countries (e.g. Austria, Finland, Germany, Italy, Poland, Spain, Sweden, Switzerland). German examples can be seen at <http://www.cleanskin.de>, <http://www.tattooofree.de>, <http://www.tattoolaser.de>, <http://www.skinshine.eu>.

Tattoos are very common these days; their prevalence in the general US population (aged 18–50 years) is approximately 25% and, in contrast to body piercing, roughly constant across age groups.^{1,2} In Germany, the prevalence is estimated to be 8.5%,³ which is more or less on par with the prevalence in most European countries.⁴

As with other fashion trends, customers gain a more critical view when the novelty has worn off, and hence tattoo removal became a major issue especially after the turn of the millennium.⁵ The quality-switched Nd:YAG lasers (implementing the principles of selective photothermolysis), in particular, provide a relatively safe and efficient removal method.⁶

Given the aforementioned figures, tattoo application and removal is obviously a major market and there is a fierce competition among providers of these services. The number of new tattoos has remained at a static rate,¹ while the number of tattoo removals is growing.⁵ In this context, tattoo studios have an obvious economic interest in offering laser removal to their clients; this secures a part of an ever-increasing market, and indeed more and more franchise studios offer this service. It is claimed that this is appropriate because tattoos are not a disease (and thus do not fall under the exclusive domain of physicians) and their removal has no side effects.

On the other hand, the medical profession – which has fiercely challenged both claims – is also under increasing economic pressure. Subsequently, their insistence that tattoo removal is indeed an exclusively medical task is neither surprising nor beyond suspicion of being motivated by financial interests.

Our frequent encounters with the undesired aftermath of laser tattoo removal by non-professionals have necessitated a thorough analysis of the medical repercussions of this practice. The present paper attempts to establish an evidence-based position the medical profession should take when it comes to laser tattoo removal by non-professionals. There is no denying that the authors S.K. and C.K. are medical professionals, but the review is completely open to another outcome – i.e., that tattoo removal by laymen is recommended – if the best available evidence suggests this is the case. In addition to a search for the most reliable medical evidence, the existing legal framework in Germany – which reflects the legal situation throughout central Europe – is analysed here.

Methods

The review is based on a thorough search through the literature in the relevant databases (MEDLINE and the Cochrane Library). The following search terms were employed:

- 1 Lasers (MeSH); laser surgery (MeSH); photothermolysis (title or abstract word).
- 2 Adverse effects (MeSH); risk* (title or abstract word); hazard* (title or abstract word); complications, postoperative (MeSH); equipment, safety (MeSH); medical staff privileges (MeSH); patient care team (MeSH).
- 3 Tattooing (MeSH).

The terms within one group were connected with a Boolean OR, and the groups among each other with a Boolean AND.

Articles with high relevance⁷ retrieved by this search were cross-referenced with the ‘related articles’ function of the web-based MEDLINE front end ‘Entrez PubMed’ (<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>). Reference lists of relevant articles were also scrutinized for related articles that might have been overlooked because of non-indexing in MEDLINE; this can affect non-English publications in particular.⁸ According to the principles of evidence-based medicine,⁹ systematic clinical trials or meta-analyses were weighed higher than individual ‘expert opinions’, regardless of the seniority of the expert.

Published material found on these databases and the World Wide Web was reviewed on the topics of laser removal of tattoos, side effects of lasers employed in tattoo removal and diagnostic difficulties created by skin diseases that are obscured by tattoos. These data were analysed for reliable and validated information about potential or actual risks as well as side effects of laser tattoo removal in the hands of laymen.

The results are discussed below in chapters dealing with the different aspects of laser tattoo removal.

Results

Local side effects of laser tattoo removal

Generally, it must be mentioned that even a non-ablative laser device can inflict serious bodily harm when used at inappropriate settings. It is a gross misconception to assume that any technical equipment with the inherent powers of a laser beam can be harmless. Hence, finding the comfort zone of treatment where clinical success is achieved and no side effects occur can be difficult, and this zone is often elusive even for a seasoned laser surgeon.¹⁰ Before the laser device is used, the specific and safe parameters (wavelength, fluence, pulse duration) for selective photothermolysis must be selected. The proper dosage should always be determined by means of a simple but professional test on an appropriate skin patch.

Hypopigmentation. In addition to the interaction with tattoo pigments, quality-switched laser devices destroy melanosomes in the skin, which are similar in size and cellular location as tattoo pigments. The greater melanin absorption seen with shorter wavelengths increases the risk of hypopigmentation. This occurs in about 5–10% of the cases^{11,12} and is mostly transient, but can be permanent;¹³ it is also more closely related to the main effect – pigment removal – than to an actual side effect and thus not limited to false usage of the laser.

Hyperpigmentation. Transient or permanent hyperpigmentation can be a result of increased UV sensitivity of the skin after laser irradiation as well as out-of-specification treatment parameters. It is more related to the patient’s skin type, with darker skin being more prone regardless of the wavelength. The incidence is normally in the same order of magnitude as that of hypopigmentation, but can be as high as 25% after repeated removal attempts.^{14,15}

Burns and scars. By design, selective photothermolysis with quality-switched laser devices should not leave higher degree burns or permanent scars. However, the depth of thermal injury depends on the spot size and energy fluence, all of which are more or less empirically used in tattoo removal.¹⁴ Textural changes are also attributable to hot spots within the laser beam and pulse-to-pulse variability. Consequently, burning and scarring after laser removal do indeed occur in several instances.¹⁶ In a study on the removal of therapy-resistant tattoos,¹⁴ we found textural changes/scars in 18.8% of treated sites, and Ho *et al.*¹⁵ reported scars in 25% of the cases. Basically, the incidence of scar formation largely depends on adequate treatment settings and especially on sufficient post-treatment wound care. The general opinion reflected in review articles that scars occur only in 1–2% of the cases¹⁷ is thus debatable and based on insufficient evidence.

Regional and systemic side effects of the tattoo pigments

The quality-switched laser targets intracellular tattoo pigment particles, leading to rapid thermal expansion that fragments pigment-containing cells and causes the pigment to become extracellular. Thus, the laser treatment mobilizes tattoo pigments into the lymphatics and blood stream. Tattoo pigments are even regularly detected in regional lymph nodes after laser removal and they can be very hard to distinguish from metastatic malignant melanoma,^{18,19} presenting a specific diagnostic challenge.^{20,21}

The distribution of tattoo pigments throughout the body is a process whose potential hazards largely depend on the substance employed by the tattooist; this information, however, is not normally provided. In general, even commercial tattoo colourants are insufficiently tested according to medical standards²² and others are not tested for toxicity at all. The regularly employed substance para-phenylenediamine, the ban of which from commercial use (e.g. in hair dyes) has been under discussion for quite a while,²³ has a substantial allergenic potential.^{24,25} Other substandard substances used in tattoos such as car paint are not manufactured for use on humans and thus their potential effects after intradermal application remain unknown.

There are few analyses of the degradation products of tattoo pigments after laser irradiation. One such study, however, has shown that azo compounds (such as 2-methyl-5-nitroaniline, 2-5-dichloraniline or 4-nitro-toluene) with proven toxic or carcinogenic potential not only emerge during the destruction of pigment, but are present in the tattoo pigment in the first place.²⁶

Engel *et al.*²⁷ showed that the UV- and laser-induced photochemical cleavage of a commonly used tattoo pigment (Red 22) yields several hazardous decomposition products that show a potential risk of being allergenic, toxic or even carcinogenic.

Whereas the concrete harm caused by the compounds under discussion awaits evidence-based assessment, the risk of allergic reactions by definition is a function of the amount of potentially allergenic substances that are present.

The clinical reactions after laser tattoo removal that have been reported so far are mainly mild-to-moderate allergic dermatitis of varying extent;^{28,29} however, generalized reactions have also been described in the literature^{13,30} implying a risk of potentially fatal anaphylaxis.

Rare complications

One particularly severe complication was reported by Rheingold *et al.*³¹ The patient in question developed severe compartment syndrome that required emergency surgical decompression after a forearm tattoo was removed using a quality-switched Nd:YAG laser. Careful review of the treatment parameters revealed that the patient had received more than twice as many pulses as were recommended. In this case, the overdose probably caused an excessive oedema that led to the acute compression syndrome, possibly in conjunction with a pre-existing marginal pressure/space relationship.

Diagnostic challenges

The literature describes a wide variety of changes to the skin which are directly related to tattoo pigments; these include pseudolymphomas,^{32–34} (systemic) sarcoidosis,^{35,36} and granulomatous or lichenoid reactions^{37,38} in addition to the allergic reactions described above. Several other dermatological conditions such as psoriasis may be exacerbated upon irritation (so-called Koebner response).³⁹ Such reactions have been described as side effects of tattooing,⁴⁰ but in principle can also occur after laser removal.

Furthermore, several malignant lesions have occurred in tattoos including basal cell carcinomas,⁴¹ B-cell lymphoma (resulting from pseudolymphoma),⁴² squamous cell carcinomas⁴³ and malignant melanomas (Figure 1).^{44–46}

As the tattoo represents a zone of darker colour that can hamper the detection of related or unrelated skin lesions in that area, the diagnosis of a melanoma within the borders of a tattoo can be extremely challenging for a dermatologist both at the clinical and at the dermatoscopic levels.^{46–50}

There are indications that chemical and physical skin exposure of various kinds can cause cancer^{51,52} and this includes the extraneous effects which typically occur during tattooing. Whether tumour growth within a tattoo is coincidental or causally related to the mechanical-chemical skin irritation that a tattoo inevitably inflicts is currently unclear;⁵³ the mere possibility that such a relationship exists, however, calls for a particularly meticulous examination of a tattoo prior to removal.

Forensic aspects

In many European countries, the right to make medical diagnoses or provide treatment to heal disease or relieve physical or psychological complaints is reserved solely for physicians. In its verdict of



Figure 1 Malignant melanoma within a tattoo resembling a granuloma pyogenicum. The 20-year-old male patient died shortly after the diagnosis (courtesy of Dr A. Frank, Tirschenreuth, Germany).

11 July 2002, the European Court of Justice expressly stated that this does not contradict European law.⁵⁴

Furthermore, the Swiss Federal Office of Public Health is among those that have published position papers on the use of laser and intense pulsed light devices in medical and cosmetic contexts. In bulletin 47/05, it reproduced an article from the Swiss Society of Dermatology and Venereology which explicitly warned about treatment by laymen.

To cite another example, the law in Denmark to date states that certain treatments, including the use of lasers, are exclusively reserved for physicians.⁵⁵ This verdict has been a consequence of scientific explorations of the aforementioned risks imposed by laser application by laymen^{56,57} and has replaced a situation that was very similar to that currently found in Germany.

In its statement on the hazards of using lasers on human skin, the German Commission on Radiological Protection [*Strahlenschutzkommission* (SSK)] declares, that '[...] cosmetically justified laser treatment of changes to the skin also must be performed exclusively by specially trained physicians. The necessary specialist knowledge is not commonly present when laser treatments are performed in hair parlours, beauty parlours etc.'⁵⁸

It is true that creating tattoos is no more a medical activity than piercing is, but the same does not apply to removing a tattoo by means of a laser device.^{59,60} The basis of this finding is §1, Paragraph 2 of Germany's Naturopathic Practitioner Law (*Heilpraktikergesetz* [HPG]), which forbids laymen from practising medicine, defined here as every 'professionally or commercially performed activity with the objective of diagnosing, healing or alleviating disease, suffering or physical damage in humans'. The emphasis is on issues of general welfare. According to legislation, medicine as defined in the HPG occurs when the activity in question is generally perceived as requiring specialist medical knowledge and when treatment can cause damage to health, although in accordance with the principal of proportionality, an insignificant and immaterial potential danger alone is not sufficient.⁶¹

In this context, the stipulated medical knowledge can be necessary because of the intention, the nature or the method of the activity itself if performing the action can cause bodily harm to the patient when done improperly.^{61,62} It is true that eliminating undesired tattoos is more a cosmetic matter than one of treating disease, as are procedures such as injections to minimize age-related facial lines. However, as indicated by the terms 'suffering' and 'bodily harm' in the HPG, the field of medicine is to be interpreted as broadly as possible here so that even physical conditions which are not technically diseases are still subject to the guidelines of the law.⁶¹⁻⁶⁴ The court has determined that cosmetic procedures can also fall under the category of 'disease' or 'suffering' as defined in § 1 Para. 2 of the HPG, as even when they are performed for aesthetic purposes, invasive procedures must also be consistent with the appropriate intended purpose.⁶⁵⁻⁶⁸

The fact that the use of laser devices in general and in particular can cause bodily harm is reflected in the discussions cited above: medical knowledge is fundamentally necessary here. There may well be exceptions in cases where the penetration depth is only minimal, for example. However, this makes no difference in interpreting the HPG, as the law applies as a general guideline for the overall use of laser devices, and it is not designed to address exceptions.^{69,70} This means that in Germany and in other central European countries, the use of lasers is forbidden for those who are not physicians.⁷¹

In contrast, in the US, laser tattoo removal may also be performed by a (licensed or certified) non-physician. On 22 February 2004, the Board of Directors of the American Academy of Dermatology (AAD) approved a position statement on the use of light emitting devices⁷² requiring that physicians must be trained in physics, safety and surgical techniques. Regarding the roles of physicians and non-physicians, the paper states: 'A physician who delegates such procedures should be fully qualified by residency training and preceptorship or appropriate course work prior to delegating procedure to licensed or certified non-physician office personnel and should directly supervise the procedures. The supervising physician shall be physically present on-site, immediately available, and able to respond promptly to any questions or problem that may occur while the procedure is being performed'.

The only stipulation there is that the 'client' is not only informed about the advantages, but about potential risks of treatment and then gives informed consent. The legal definition of 'informed consent' generally entails comprehensive data about the benefits and risks of the procedure in question, including any rare complications.⁷³ A spot check at a local tattoo studio in Germany revealed an information leaflet (available from the corresponding author upon request) which mentions side effects only in their most basic form ('Colour alterations/pigment residues', 'skin irritation/swelling', 'hypo-/hyperpigmentation', 'slight scarring' [translated from German]) with no reference to their respective frequency or any of the aforementioned systemic effects, rare complications and diagnostic challenges.

In England, the Care Quality Commission regulates all independent clinics and hospitals which provide treatments that use lasers and intense pulsed light, and they must be registered and inspected. The use of lasers is not restricted to physicians, but nevertheless several standards must be met. These include a protocol produced by an expert medical or dental practitioner who sets out the necessary pre-treatment checks and tests the manner in which the procedure is to be applied, the acceptable variations in the settings used and when to abort a treatment. In particular, the protocol addresses:⁷⁴ contraindications, treatment technique, pre-treatment tests, post-treatment care, recognition of treatment-related problems and procedure if anything goes wrong. All staff using lasers and intense pulsed lights have regular update training, both planned and in reaction to relevant technological and medical developments.

Discussion

Advertisements of tattoo studios suggest that tattoo removal is easy and uncomplicated, which (deliberately, one assumes) lowers the threshold for obtaining a tattoo in the first place. First of all, it must be emphasized that this claim is false, regardless of its source: complete removal can never be guaranteed even in experienced hands and removal of professional tattoos often requires up to 15–20 treatment sessions at 4–6 week intervals.⁶ Consequently, it will take over a year to remove a tattoo and be quite costly.

The question, 'Who should be allowed to use laser devices for the removal of tattoos?' currently has only one answer: well-trained dermatologists or supervised healthcare professionals with profound clinical knowledge and adequate training in laser device usage. This judgement is mainly based on four points:

1 The composition and thus the hazardous (and allergenic) potential of the pigments used in tattooing are mainly unknown. Laser removal of a tattoo inevitably releases degradation products into the lymph nodes and blood stream. Only a trained physician is able to detect the complications that can occur as a result and, equally importantly, treat them. This situation could be substantially improved if legal requirements about the composition and administration of tattoo colourants were to be established (and enforced); in Germany, an appropriate regulation has become effective in May, 2009.⁷⁵

Allergic reactions can doubtlessly occur after tattoo removal by a trained physician as easily as they can with a medical layman, but the former is definitely much more capable of detecting the complication and taking swift and appropriate action to treat it. Indeed, laser removal of tattoos can represent a major threat to the health (or potentially even the life) of a patient when performed by non-professionals. There can be no reasonable argument about the statement that even the most remote possibility of an anaphylactic reaction makes the presence of a properly trained physician desirable, if not critical. Furthermore, if a patient exhibits a local immediate hypersensitivity reaction, a physician might consider prophylaxis with systemic antihistamines and/or corticosteroids prior to subsequent laser treatments.

2 Laser devices can inflict very serious and potentially fatal bodily damage when not used in compliance with the manufacturer's specification and the guidelines established by the medical-scientific community. As tattooists are unlikely to know (and to be able to comprehend) the latter, this basically rules out the use of laser equipment on humans outside the medical profession altogether (including hair removal or the like).

3 Tattoos can obscure malignant skin disease (and possibly contribute to its development). The risk cannot be assessed at the moment owing to the lack of empirically sound data, and a global estimate would be hardly instrumental as the

concrete hazard will depend on the tattoo colour and density, possible scarring and the individual skin type. Thus, prior to tattoo removal, the skin has to be carefully inspected for signs of malignant (or other) skin disease; this task can be challenging even for a well-trained dermatologist and is surely beyond the ability of any layman. Here, we must emphasize that when changes in the skin or dermatological diseases are present, a specialist must conduct a differential diagnosis so as to document any conditions and commence appropriate treatment (Figure 1).

4 Tattoo removal requires the provider of the service to obtain informed consent; without consent, they commit the felony of battery. Invasive procedures of a cosmetic nature fundamentally require particular diligence when it comes to informing patients about possible risks. The guiding principle here is that there is an inverse correlation between the extent to which a procedure is indicated and the thoroughness of the informed consent process. As medical laymen are hardly able to interpret possible complications and contraindications of laser-assisted tattoo removal, let alone explain them to another layman, strictly speaking, it is impossible for them to fulfil this demand. Even in the hands of an expert with extensive experience and skill, cosmetic laser surgery can have very serious side effects, the diagnosis and swift management of which require sound clinical knowledge.¹⁰ Such complications are rather infrequent after laser tattoo removal by an expert, but their likelihood is increased when the procedure is performed by a non-professional, and moreover, laymen are unable to detect and treat them.⁷⁶

Conclusions

The greatest risk in aesthetic laser medicine is the operator. Modern lasers are being used widespread for reasons of their supposed ease of use, unrestricted availability and falling acquisition costs. However, these lasers are often operated by people who do not understand the mechanism of action and potential risks of such powerful systems. This practice is in stark contrast to the legal framework in most central European countries and indicates a chasm between legislation and reality.

For several medical and legal reasons, tattoo removal by medical laymen cannot be accepted and we hope to have presented sufficiently compelling evidence above to ban this practice. Serious skin diseases embedded in the tattoo can be overlooked and major side effects, although rare, can occur. At the time of this writing, a reliable incidence figure cannot be presented. Indeed, this is another reason to vote in favour of making tattoo removal the exclusive domain of medical professionals. Only in a controlled professional environment can side effects be reliably detected.

As the health care system has to deal with the consequences of tattoo removal, it should also be entitled to decide about the indication and perform the procedure exclusively.

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