REVIEW ARTICLE
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Complications of tattoos and tattoos removal: state-of-the-art in Italy

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Abstract

Introduction: Modern tattoo removal began as a science approximately 20 years ago, and relatively few advances have been made since then. The aim of this study is twofold: first, to review the complications of tattoos and tattoo removal methods and second, to investigate both the epidemiology and legal issues of this phenomenon in Italy.
Discussion: Complications of medical tattoos are changes in colour, leading to colour mismatch. The complications of decorative tattoos include infections and allergic and foreign body reactions. Tattoos are popular in Italy, especially among the younger generations. As these people age, the demand for tattoo removal will continue to grow. Q-switched (QS) lasers are widely considered the gold standard for tattoo removal. Although Q-switched lasers are capable of removing tattoos without harming the skin, removal often requires numerous treatments and it can still be incomplete, especially when attempting to remove multi-coloured tattoos. Moreover, complications can occur, with an incidence of about 5%. Immediate complications include pain, blisters, crusting and pinpoint haemorrhage. Delayed complications include pigmentary changes, either hypopigmentation or hyperpigmentation. Developments leading to removable tattoo inks, feedback systems to detect the absorbance characteristics of tattoo inks, dermal clearing agents and, perhaps, even shorter pulse-duration lasers should result in improvements in tattoo removal in the near future.
Conclusions: In Italy there is no specific prescriptive legislation for tattooing, and there is also a great diversity in terms of regional regulatory approaches. Future educational campaigns by school counsellors and primary care physicians should also be aimed at specific groups that are more likely to get tattoos, such as minors and women.

KEY WORDS: lasers; laser treatment; Q-Switched Lasers; tattoo; tattoo removal.

Riassunto

Introduzione: La rimozione dei tatuaggi nasce come scienza circa 20 anni fa e da allora pochi progressi sono stati fatti. Scopo di questo studio è duplice: da una parte, quello di fare una revisione della letteratura sulle complicanze legate ai tatuaggi e alle tecniche di rimozione dei tatuaggi, dall'altra quello di indagare la diffusione e gli aspetti normativi di questo fenomeno in Italia.
Discussione: Le complicanze che possono conseguire ai tatuaggi effettuati per motivi "sanitari" sono le discromie, mentre i tatuaggi di tipo "decorativo" possono causare infezioni, reazioni allergiche e da corpo estraneo. I tatuaggi sono popolari in Italia, specialmente tra i giovani; pertanto le richieste di rimozione aumenteranno in futuro. Il Q-switched Laser è considerato oggi il gold standard per la rimozione dei tatuaggi. Tuttavia, anche se tale laser li rimuove senza danneggiare la cute, spesso richiede numerosi trattamenti e può dare risultati parziali, specialmente sui tatuaggi multicolore. Inoltre, tale tecnica può portare a complicanze di tipo immediato come la comparsa di dolore cutaneo, vescicole, croste e petecchie emorragiche o di tipo ritardato come l'iper o l'ipopigmentazione cutanea. Lo sviluppo di inchiostri rimovibili, di sistemi di feedback capaci di rilevare le caratteristiche di assorbimento degli inchiostri, l'utilizzo di agenti chimici e forse di laser ad impulsi di durata più breve dovrebbero portare in futuro a dei miglioramenti.
Conclusioni: In Italia non esiste una normativa specifica per i tatuaggi e c'è una grande diversità dal punto di vista normativo tra le regioni. Campagne educative scolastiche e da parte dei medici di base dovrebbero essere rivolte ai gruppi particolarmente a rischio come donne e minori.

TAKE-HOME MESSAGE

The average tattoo removal patient is young and female, and the tattoos are made with easy-to-remove black ink. New technologies on the horizon will offer opportunities to more effectively and more quickly remove a patient's tattoos in the future.

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INTRODUCTION

The etymological origin of 'tattoo' is believed to have two major derivations: the first is from the Polynesian word 'ta', which means striking something, and the second is the Tahitian word 'tatau', which means 'to mark something' [1]. The use of tattoos is reported to have begun thousands of years ago. What have changed over the millennia are the millions of colours that can now be used to make tattoos on the body. Its origins are thought to go back to the initial migration and colonisation of the Pacific, where people from Southeast Asia migrated eastward and colonised numerous islands throughout their travels. Numerous figurines, dating to 4000 years ago, depicting body tattoos have been discovered. In 1991, Otzi the Ice Man, made newspaper headlines all over the world when his frozen body, with 61 tattoos, was discovered on a mountain between Austria and Italy. Although tattooing is an ancient practice [2], in recent times, there has been a dramatic increase among teenagers and young adults in obtaining tattoos as a cosmetic and decorative form of body art. Modern tattoo removal began as a science approximately 20 years ago, and relatively few advances have been made since then. The reasons for getting a tattoo are almost as varied as the designs themselves. For example, names are one of the most common types of tattoos that are presented for removal when patients have a change of heart (or a change of faith in the case of religious symbols) [3]. Although popular, tattoos are often regretted, subsequently, for different reasons, including the desire to improve physical appearance; the loss of art value or uniqueness; the end of a relationship; conformity and peer pressure; family pressure; severing ties with a previous stage of life; the end of group/gang affiliation; increased employment chances; embarrassment and social rejection/stigma [4]. The desire to remove such tattoos is often acute.

DISCUSSION

Complications of tattoos

Tattoos are created by the introduction of exogenous pigment into the dermal skin layer, and they can be placed with intent or be the result of accidents and trauma. Tattoos can broadly be divided into the following categories: professional, amateur, cosmetic, traumatic or medical [5]. According to Khunger et al., complications of medical tattoos, which are used to camouflage certain medical conditions, such as resistant vitiligo, breast areola reconstruction following surgery, scar camouflage following burns or surgery and hair camouflage for permanent hair loss following radiation or craniofacial surgery, are changes in colour, leading to colour mismatch [6]. The complications of decorative tattoos include infections (viral disease, bacterial and fungal infections) and allergic and foreign body reactions. The first complication can occur because tattooing involves physical injury to the skin that may promote the transdermal transmission of viral and bacterial infections, depending on the hygiene conditions during tattooing. The second complication is caused by the classic pigments and degradation products used in tattooing, such as dichromate (green), cobalt (blue), cadmium (yellow) and mercury salt (red)-based pigments, and by contamination of pigments with nickel sulphate. Thus, infections are less common in medical tattoos than in decorative tattoos.

Limitations and complications of methods for tattoo removal

Attempts at tattoo removal may date back many millennia. Historically, people have used abrasives to traumatise the surface of the skin, subsequently applying irritants and other compounds to the skin's surface in an attempt to draw the tattoo particles out through the open wound. Physicians have used dermabrasion with metal or diamond-coated fraises or abrasive salts (salabrasion), often with the addition of wound dressings that were thought

to help remove tattoo pigment through the skin. Using salt or other materials with rough surfaces, such as sandpaper, can also remove the surface of the skin in an attempt to remove the tattoo. The resulting inflammation enables removal of some of the tattoo pigment. Salt is one of the more common agents used to abrade the surface of the skin. These destructive modalities are not recommended for modern tattoo removal, and they carry a significant risk of hypertrophic scarring or keloid formation after the procedure. Extreme heat or cold can be used to destroy the superficial layers of skin, with resulting inflammation and tattoo removal, but this approach causes significant scarring. Physicians use thermal methods to remove tattoos, including destructive lasers, such as a carbon dioxide (CO2) laser, which destroys the superficial layers of skin, affecting removing of a tattoo [7–9]. However, these thermal methods of tattoo removal almost always leave a scar.

Virtually all of the above-mentioned thermal methods for removing tattoos lead to incomplete tattoo removal with significant scarring [10–12]. Present-day tattoo needles inject ink granules into the superficial to mid-dermis. This ink placement requires the use of deeply penetrating lasers to achieve tattoo removal. The following short-pulsed, high-intensity and pigment-selective Q-Switch (QS) lasers are widely used today for tattoo removal: the Q-switched ruby laser (QSRL), which emits light at a wavelength of 694 nm and has a pulse duration of 28-40 ns; the Q-switched alexandrite laser (QSAL), which has a near infrared wavelength of 755 nm, pulse duration of 50-100 ns, spot size of 2-4 mm and a repetition rate up to 10 Hz; and the Q-switched neodymium-doped yttrium aluminium garnet (QS Nd:YAG) laser, which emits infrared light at 1064 nm and has a pulse duration of 5-10 ns, spot size of 1.5-8 mm and a repetition rate up to 10 Hz. The frequency can be doubled and the wavelength can be halved (532 nm) by passing the laser beam through a potassium titanyl phosphate (KTP) crystal. The broad absorption spectrum of the tattoo pigments suggests that different types of QS lasers are needed to remove variedly coloured tattoos. Although QSRL and QSAL are the lasers that were first used for tattoos, the QS Nd:YAG laser (1064 nm), due to its longer wavelength, higher fluence and shorter pulse, has emerged as the prototype laser for black and dark blue/black tattoo pigments [13]. Argon or cw-CO lasers, as well as intense pulsed light sources, should not be used for tattoo removal since they often produce significant scarring [4]. Other lasers use crystals to alter the emitted wavelength of the Q-switched lasers, producing other wavelengths that are effective for removing some difficult-to-remove colours.

The lasers that are currently available for tattoo removal were not simply selected because they are the best wavelengths for removing tattoos. The discovery of selective photothermolysis has made it possible to remove tattoos without leaving a scar. Q-switched neodymium: yttrium-aluminium-garnet, alexandrite and ruby lasers with pulse durations in the nanosecond domain fulfil this need [14]. The Nd:YAG laser emits in the infrared region at 1064 nm. That wavelength of light is invisible to the human eye, but reacts with tissue in a similar fashion to the ruby and alexandrite wavelengths, which appear red when viewed. Comparative studies such as this are very difficult to perform, as one must look at the highest tolerated fluences available from each device. Because the spot sizes of these devices vary, they also offer slightly different pulse durations, and although all are in the nanosecond domain, comparisons are difficult. In modern clinical practice, having only one laser for removing tattoos may only suffice for removing black tattoos. However, even when treating black tattoos, the ink may become refractory to a single type of laser, necessitating the use of another type of tattoo laser to achieve complete removal [15–24].

Nowadays, even though Q-switched lasers are the current gold standard for laser tattoo removal, certain limitations exist when following the standard protocol, including incomplete clearance, long total treatment duration with a large interval between ses-

sions, ink retention, despite multiple sessions and treatment-associated side effects, such as blistering and dyschromia. Moreover, complications can occur, with an incidence of about 5% [25]. Immediate complications include pain, blisters, crusting and pinpoint haemorrhage. Delayed complications include pigmentary changes, either hypopigmentation or hyperpigmentation. These pigmentary complications occur 4-6 weeks after laser treatment, and most are transient. However, longer-lasting pigmentary alterations can occur, especially in darker or tanned skin [26]. The most recent techniques include a combination of imiquimod, a topical immune response modulator, and Q-switched laser (based on the limited studies, the use of imiquimod in combination with QSL is currently controversial), the application of Diascopy in combination with QSYL to reduce pain and decrease epidermal damage during laser tattoo removal, and the application to the skin of an optical clearing agent, such as glycerol, dimethyl sulfoxide and glucose, before laser irradiation to increase the efficiency of laser tattoo removal [27]. In the early part of 2013, picosecond lasers with pulse durations in the range of 50–100 picoseconds were introduced commercially. Recent studies by Brauer et al. demonstrated the efficacy of a 755 nm picosecond laser in treating blue and green tattoos [28, 29]. However, although effective and safe on Caucasian skin, their safety remains to be evaluated in pigmented skin. Furthermore, their exorbitant cost makes them a less attractive option in our scenario. Finally, monotherapy with QSL is often effective for tattoo removal, but combining a QS laser with an ablative fractional laser or a nonablative fractional laser may yield faster clearing, minimise the number of sessions and reduce the side effects [26]. The combination can be in any order; Fractional Laser (FL) followed by QSL helps reduces blister formation. According to Marini, a combination of fractional Er:YAG laser skin conditioning followed by the use of a QS Nd:YAG laser led to a 30% reduction in the number of sessions [30]. Successful removal of the tattoo depends on various factors, including the type of tattoo and the dye used, the depth of the tattoo pigment, the type of lasers used and the different techniques applied when using a combination of lasers. In addition, it is largely dependent on the wavelength and fluence of the lasers used. Future innovations in laser technology, as well as newer, easier-to-remove tattoo inks, should enable more effective tattoo removal in the future, possibly requiring only a single device. Laser-tissue interactions are most about the wavelength of the administered light and its absorption into a chromophore in the skin. Because of the wide range of colours present in modern tattoos, this interaction can be dramatic, and it can be seen first-hand when removing tattoos.

State-of-the-art of tattoos in Italy and implications for the future

In Italy, tattoos and permanent make-up have become increasingly popular in recent years. The number of tattoo parlours has increased from 257 in 2009 to 2,055 in 2014 [31]. According to a survey conducted by the Istituto Superiore di Sanità [31], in Italy about 7 million people have tattoos (12.8% of the Italian population). Moreover, tattoos are more common among women (13.8% of respondents) than men (11.7%). One person was 25 when receiving the first tattoo, but most of the respondents were between the ages of 35 and 44 (29.9%). Among the participants who were minors, the percentage was 7.7%. Most of the respondents were satisfied with their tattoo (92.2%), but a high percentage (17.2%) said they wanted to remove their tattoo and, of these, 4.3% has already done so. Men prefer tattooed arms, shoulder and legs, and women preferred tattooing their back and ankles. One in four tattooed people (25.1%) resides in Northern Italy, 30.7% have a university degree and 63.1% are employed. According to the survey, 3.3% of the respondents claim to have had complications or reactions related to their tattoo, including: pain, granulomas, thickening of the skin, allergic reactions and bacterial infections. In all these cases, only 12.1% of the respondents went

to a dermatologist or family doctor (9.2%) to treat their condition, and 27.4% returned to their tattoo artist, but more than half (51.3%) did not consult anyone. However, in general, only 58.2% of the respondents were aware of the hazards associated with tattooing. Their perception of the most frequently considered risks was: allergic reactions (79.2 %), hepatitis (68.8%) and herpes (37.4%). Only 41.7% of the respondents were adequately informed about contraindications to the practice of tattooing.

In Italy, there is no specific prescriptive legislation for tattooing. The Italian regulatory framework for the field of tattoos and permanent make-up is limited to the guidance of the Ministry of Health guidelines for the safe execution of tattoo and piercing procedures [31, 32]. The Ministerial guidelines take into account the risk of transmission of infections caused by blood-borne pathogens as well as skin infections and toxic effects due to the substances used for the pigmentation of the dermis. The measures, reported to be applied for risk control, include: general hygiene rules, barrier measures and universal precautions as well as environmental control measures. This document has not been adopted by all Italian regions, creating a highly fragmented situation. ResAP(2008)1, which is not mandatory in Italy but was made binding by Italian Decree n. 206/2005, has been applied uniformly throughout the country. Thus, the surveillance system has highlighted the presence of non-compliant inks and potentially unsafe preparations for tattoo removal in the market [31].

CONCLUSION

Few cosmetic laser procedures are as exciting and profitable as laser tattoo removal. The popularity of tattoos matched with the high prevalence of 'tattoo regret' has caused millions of patients to seek tattoo removal. People who get tattoos transcend all demographics and defy all stereotypes. Statistics about the tattoo market indicate the potential for tattoo removal market growth. Tattoos are popular in Italy, especially among the younger generations. As these people age, the demand for tattoo removal will continue to grow. The average tattoo removal patients are young and female, and they have easy-to-remove black tattoos. New technologies on the horizon will offer opportunities to more effectively and more quickly remove a patient's tattoos in the future. In Italy, there is also a great diversity in terms of regional regulatory approaches. Some regions have adopted the Ministry of Health guidelines, issuing laws or other normative acts to govern tattooing, while some regions have not adopted any measures, which may be a problem, as it does not guarantee equal protection for all citizens. Therefore, there is the need to harmonise standards and training for tattoo parlour operators. Future educational campaigns by school counsellors and primary care physicians should also be aimed at specific groups that are more likely to get tattoos, as such minors and women, dissuading children from impulsive tattooing, a practice often undertaken to comply with a social fashion or conform to peer pressure [4].

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