When a Tattoo Is No Longer Wanted: A Review of Tattoo Removal

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Tattoos have been adorning human bodies for thousands of years. They most commonly are used as a medium of expression as well as a way of showing membership or allegiance to a specific demographic group. Additionally, tattoos are used as tools in medicine to permanently mark the skin when performing radiation treatment.

The removal of tattoos is more complicated than placing them on the skin. Many modalities have been used over the years including excision, abrasion, and laser therapy. Although the perfect method of tattoo removal has not yet been invented, the quest continues. The advent of newer and more sophisticated lasers employing selective photothermolysis has pushed this quest to greater success. Until the ideal method of removing tattoos arrives, individuals should carefully and deliberately consider the implications of what they are etching into their skin.

The word *tattoo* comes from the Polynesian *tattau*, an onomatopoeia representing the sound of the hammer hitting the small bones that the Tahitians used to etch dye into the skin. The first evidence of tattoos was found on Egyptian women dating back to 2000 BC. Some believe these Egyptian women were prostitutes adorned with tattoos to keep away spirits and protect themselves from sexually transmitted diseases. Others believe that tattoos on these Egyptian women were used for therapeutic purposes or functioned as an amulet during the painful processes of pregnancy and childbirth.[1]

In a 2006 study on tattoos and body piercings in the United States, a total of 253 women and 247 men aged 18 to 50 years (with equal age distribution) were surveyed.[2] Of the participants, 24% were adorned with at least 1 tattoo with incidence being equally common in both men and women. Of these respondents, the highest incidence of tattoo adornment was found in individuals born in 1977-1980, with approximately 42% of this age range containing a tattoo.[2] Although individuals of all ages choose to get tattoos, the peak incidence is between the ages of 14 and 22 years.[3]

Individuals may choose to get a tattoo to pay homage to a loved one, either living or deceased. Tattoos also are used to mark and honor a life-changing event such as the beginning or end of a relationship. Other tattoos may be a symbol that represents overcoming a substantial obstacle or achieving a notable turning point in life. Sometimes members of certain gangs get specific tattoos as a symbol of their commitment and loyalty; their tattoos are a way of flaunting their membership and distinguishing them from the rest of society.

From the dermatologist's perspective, there are risks associated with getting a tattoo, including allergic

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reactions and diseases. The removal of tattoos is more complicated than placing them on the skin. This article reviews potential complications of getting a tattoo and ways to remove a tattoo.

DANGERS AND RISKS OF GETTING A TATTOO

Individuals may have allergic reactions to tattoo ink and experience itching, swelling, and tenderness around the site of the tattoo, which may occur years after receiving the tattoo. Intensely colored, plastic-based pigments have been reported to polymerize under the skin, with the pigment converging to form a solid slate underneath the skin. Glow-in-the-dark ink has been reported to be toxic and radioactive.[4-6] Furthermore, allergic reactions have been reported from some of the metal ingredients found in tattoo ink, such as nickel, copper, and lead.[4] Tattoos also can lead to skin infections, causing pain, swelling, and drainage from the infected areas. Granulomas, keloid formation,[5] dermatitis, exacerbation of psoriasis, and tumor formation (benign and malignant) also can occur.[6]

Tattoos may contain hazardous chemicals that pose a serious health threat such as carcinogens, mutagens, and teratogens. Inherent to the risk for getting a tattoo is contracting a blood-borne disease if the equipment used is contaminated with infected blood. These diseases may include human immunodeficiency virus, *Staphylococcus*, and herpes simplex virus infections, as well as hepatitis B and C, syphilis, and tetanus. Additionally, some hospitals and testing centers refuse to perform magnetic resonance imaging on patients with tattoos because some metal ingredients in tattoo ink may cause a severe burning sensation during the scans.[3]

TATTOO REMOVAL

In most instances, individuals get tattoos that they believe they will appreciate forever. If the tattoo is visible at all times or is controversial in nature, the individual may opt for tattoo removal out of fear that he/she will be prejudged by others on the basis of the tattoo. Some tattoos are symbolic of membership in an organization, gang, or social group with which affiliation is no longer desired. At times, removal is done at the request of another person. In certain instances, the rationale for removal is medical. Certain pigments are more likely to lead to allergic reaction, inflammation, infection, granuloma formation, and other complications.[5-7] In these cases, removal of the tattoo is to relieve symptoms caused by the foreign material that has been deposited in the skin. Interestingly, this phenomenon often was successfully treated with the CO_2 laser prior to the development of more sophisticated technology. Removal was purely ablative in nature with the use of nonselective heat. Concern about possible systemic dissemination of the allergy-inducing pigment should be considered (Figure 1).[8-10]

Cosmetic tattooing such as lip liner, eyeliner, blush, eyebrows, or other such adornments has become more popular. As one can imagine, sometimes the results meet

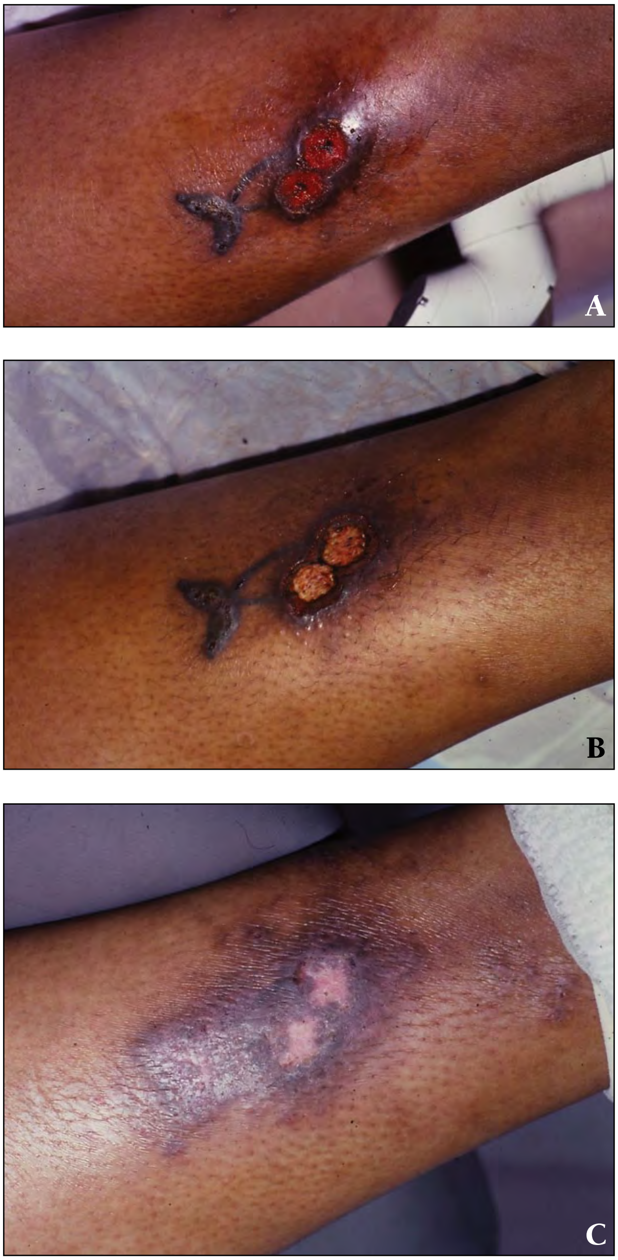

Figure 1. Prior to treatment with a CO_2 laser, a patient experienced an allergic granulomatous reaction to the tattoo ink (A). The patient only requested treatment of the red area of the tattoo with the CO_2 laser (B). Eight months following removal of the red ink there was no evidence of granulomatous inflammation (C); symptoms of itching and tenderness disappeared.

the individual's expectations, but in other instances, the outcome is suboptimal or undesirable (Figure 2).[11-14]

Not all tattoos are ornamental in nature. Typically, radiation oncologists place tattoo dots on the body to demarcate the areas to be treated. For some patients, these radiation markers are a constant reminder of a disease they would just as soon forget. There is some difference of opinion among radiation oncologists regarding removal of these tattoos. The type of tumor treated, the age of the patient, and the length of time since the radiation was administered are factors that must be considered prior to removing these tattoos. It is advisable to have patients obtain permission from their radiation oncologist prior to removal.[15,16]

Other types of tattoos are literally traumatic in nature. Bicyclists, skateboarders, rollerbladers, and other road warriors can sometimes meet an undesirable fate with the street.[17-19] Although the body does its best to rid itself of these objects through transepidermal elimination, in many cases remnants remain, resulting in a traumatic tattoo. Laser treatment can be employed as a final step after the wound has healed and as much macroscopic debris as possible has been removed. Because the foreign material may be black or dark in color, it can be easily targeted via selective photothermolysis.

Surgical Excision

For individuals who have found that their tattoos have become objects of scrutiny, controversy, remorse, or disdain, there are a variety of options for removal. One of the most direct, intuitive, quick, and permanent methods of tattoo removal is surgical excision.[20-22] As is the case with any surgery, there will be a scar. It is critical for the patient and surgeon to be on the same page when discussing excision of a tattoo. Optimal results from surgical excision are best achieved when the tattoo is small, in an area of tissue laxity, and in a region of minimal cosmetic concern. Because many patients have tattoos removed for cosmetic reasons, the cosmetic result is paramount. However, patients often verbalize that they would much rather have noticeable, even somewhat objectionable scars than have their tattoo. These patients may be much more willing to undergo surgery, even if there is a notable scar. It is often preferable to perform serial excisions in an attempt to remove the tattoo with the smallest possible scar. Additionally, it may be physically impossible to remove it all at once. Tissue creep and dermal relaxation with time can allow serial excisions to be more effective. Sometimes tissue expansion can be used to stretch the skin surrounding the tattoo, providing additional skin for closure. The patient must be willing to undergo the discomfort and cosmetic nuisance of having the expander(s) in place. It is critical to position the expander to stretch the surrounding tissue while leaving the tattoo static; stretching the tattoo itself would be counterproductive. Sometimes a combination of modalities can be used. For example, part of the tattoo could be easily removed with excision, and the remaining portion could be removed using a laser or other nonexcisional method.[20-22]

Figure 2. A patient who underwent eyebrow tattooing was unhappy with the results and sought laser removal.

Abrasion

Another method of tattoo removal is abrasion, which can be accomplished in several ways. Salabrasion uses a slurry of salt to abrade the skin.[23-27] Dermabrasion typically refers to using a diamond fraise or wire brush attached to a hand engine. The area is either anesthetized with local anesthetic or sprayed with topical refrigerant. The skin is held tightly in place with the help of an assistant and sanded. The process is facilitated by spraying topical refrigerant (dichlorotetrafluoroethane 75% and ethyl chloride 25%). The refrigerant anesthetizes the skin and makes it rigid, facilitating dermabrasion and reducing the chance that the skin will either move or be snagged by the fraise or the wire brush. If the abrasion is deep enough, it removes some of the pigment as it removes the stratum corneum, epidermis, and part of the dermis. Once the depth of abrasion goes beneath the mid dermis, scarring will be more severe. However, even if the abrasion does not extend to the depth of the tattoo, the inflammation can stimulate transepidermal elimination of some of the deeper pigment as the wound heals.[27-29]

Lasers

Prior to the advent of selective photothermolysis, the CO_2 laser was frequently used to remove tattoos.[30-33] LASER is an initialism for light amplification by the stimulated emission of radiation. The light emitted from a laser is collimated, coherent, and monochromatic. The CO_2 laser operates at a wavelength of 10,600 nm. The target of the light beam is water. Essentially, the laser causes the skin to boil because it has such high water content. The boiling action creates heat in the skin and a burn. The depth of the burn will determine how much of the tattoo is removed as well as the type of scarring that results (Figure 3).

A huge advancement in our ability to remove tattoos came with the implementation of selective photothermolysis.[34,35] Using water as the target for the laser energy was very sensitive but not specific; all of the tissue (the tattoo as well as the normal surrounding tissue) was treated by the same modality. The concept of selective photothermolysis is that there is a specific target or chromophore that will specifically absorb a given wavelength of light. Because laser light is monochromatic, there are a limited number of chromophores that will specifically absorb its energy. For this reason, multiple wavelengths usually are needed to remove tattoos with multiple colors. Because there are no specific "recipes" for making tattoo pigments, the results of treatment are somewhat unpredictable as well as the number of sessions that will be needed. We do know through years of treating tattoos that certain colors tend to be more difficult to remove. In some instances, dark black or blue pigment can be removed in 2 to 4 sessions (Figure 4). Certain greens, yellows, oranges, and purples are notoriously refractory to treatment and can take more sessions to remove, sometimes with minimal success.

There are several other lasers that are commonly employed for tattoo removal, including various Q-switched (quality switched) lasers such as ruby (694 nm), Nd:YAG (532 and 1064 nm), and alexandrite (755 nm) lasers.[36-39] Q-switching is a technique in which the laser emits short pulses of extremely high energy, while other lasers emit a continuous wave of energy. These extremely powerful bursts of energy coupled with selective photothermolysis of the specific wavelength blast apart the microparticles of pigment comprising the tattoo. Each laser attains its specific wavelength by allowing light to pass through a medium, such as a crystal (eg, ruby, yttrium-aluminum-garnet, alexandrite). The wavelength of light that emerges after passing through the crystal is what gives the laser

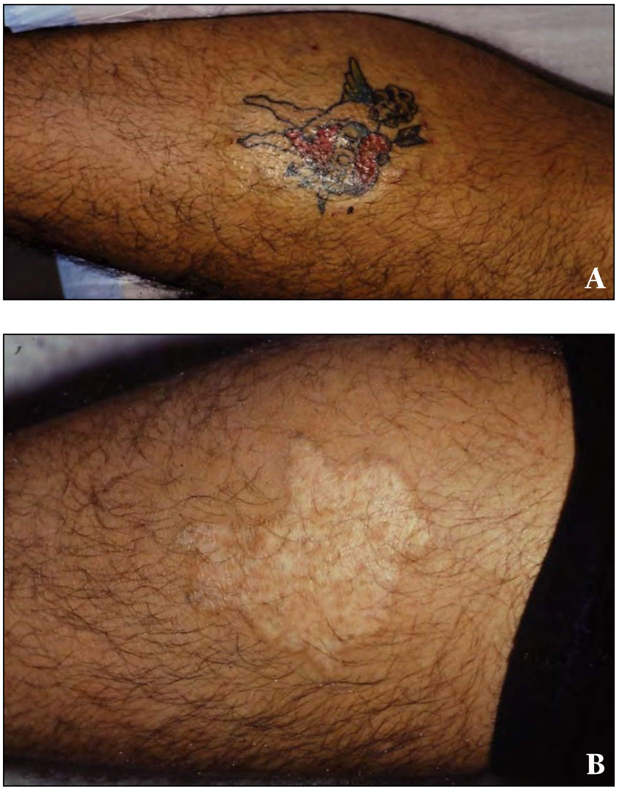

Figure 3. A patient with a tattoo on the right lower leg before (A) and 2.5 years after CO_2 laser treatment for tattoo removal (B).

Figure 4. A patient with a dark-colored tattoo on the back before (A) and 2 years after treatment with the Q-switched Nd:YAG laser (1064 nm)(4 treatment sessions)(B).

its specific property. In lighter skin, the risk for altering the normal pigmentation of the skin is reduced. However, in patients with skin of color, more care must be taken to specifically target the tattoo pigment, leaving the normal pigmentation less disturbed. In these instances, the longer wavelength of the Nd:YAG laser (1064 nm) is more suitable because it penetrates more deeply into the skin, bypassing the more superficial tissue where the susceptible melanocytes reside (Figure 5).[40-45] Fractionated lasers such as CO_2 and erbium, in both nonablative and ablative versions, have been combined with the family of Q-switched lasers to enhance pigment removal.[46,47]

Complications of Lasers

Although the actual technique of using lasers for tattoo removal can be easily learned, the subtleties of when, where, why, and how to treat a specific patient are legion. It is important for laser operators to be well versed on the physiology of the skin as well as the physics of each laser being used. Complications can certainly arise even in the most skilled hands, as is the case with any medical or surgical procedure. Typically encountered complications and/or side effects of laser tattoo removal include infection; crusting; pigment alteration of the skin, either hypopigmentation or hyperpigmentation; lack of complete removal; disappointing results; and scarring.

Figure 5. A patient with a tattoo on the chest before (A) and after 5 sessions with the Q-switched Nd:YAG laser (1064 nm)(B).

The perfect method of tattoo removal still does not exist, and there is no guarantee that complications will not arise. As technology evolves, so does the future of laser tattoo removal. Care must be taken with ablative lasers not to induce the type of scarring that has been seen with the fully ablative traditional CO_2 lasers.

Future Directions

There have been recent advances in the actual technique of using lasers. The physics of lasers remain the same, but the scientific refinements continue. The premise of Q-switched lasers and creating extremely short, high-energy bursts of power to the specific tattoo pigment will serve as the foundation for creating newer and better lasers, such as picosecond lasers.[48] Picosecond lasers were developed to deliver shorter pulse duration bursts with very high energy. The rationale is that these bursts more closely approximate the thermal relaxation time of the particles that are being targeted.[49] A study of patients with multicolored and refractory tattoos using a 755-nm, 750- to 900-picosecond laser at fluences of 2.0 to 2.8 J/cm^2 showed picotechnology to be extremely effective after 1 or 2 treatments in reducing tattoo pigment, with impressive clearing of the notoriously difficult blue, green, and purple colors. Notably, no scarring or adverse pigment changes were noted.[48]

As technology advances and better lasers are developed, there will be improvement in our ability to remove tattoos. Additionally, we may be able to more effectively treat hypopigmentation that can result from prior removal, disease, or other types of scars. Advances such as using the erbium-doped fractionated laser in conjunction with topical bimatoprost have been helpful in repigmenting hypopigmented scars.[50]

CONCLUSION

Individuals have been adorning themselves with tattoos for years and in all likelihood will continue to do so. Being human, some decisions that we make we come to regret. Treatments are evolving to help get rid of what we may consider a mistake. We still do not have a perfect "eraser," but the medical and scientific communities are working toward it.

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