

Tattoos: From Ancient Practice to Modern Treatment Dilemma



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Tattoos have a long history in the United States and the world. As dermatologists, we often treat patients who regret their tattoos and are seeking to have them removed. Laser technology allows for more effective tattoo removal. There are many unique risks to tattoo removal compared to general laser procedures, including paradoxical tattoo ink darkening and even allergic reactions to tattoo ink. Given the persistence of tattoos throughout history, this treatment challenge will likely persist for many years to come.

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As dermatologists, we possess a vast knowledge of the epidermis. Some patients may choose to use the epidermis as a canvas for their art in the form of tattoos; however, tattoos can complicate dermatology visits in a myriad of ways. From patients seeking tattoo removal (a complicated task even with the most advanced laser treatments) to those whose native skin is obscured by a tattoo during melanoma screening, it is no wonder that many dermatologists become frustrated at the very mention of the word *tattoo*.

Tattoos have a long and complicated history entrenched in class divisions, gender identity, and culture. Although its origins are not well documented, many researchers believe that tattooing began in Egypt as early as 4000 BCE.¹ From there, the practice spread east into South Asia and west to the British Isles and Scotland. The Iberians in the British Isles, the Picts in Scotland, the Gauls in Western Europe, and the Teutons in Germany all practiced tattooing, and the Romans were known to use tattooing to mark convicts and slaves.¹ By 787 AD, tattooing was prevalent enough to warrant an official ban by Pope Hadrian I at the Second Ecumenical Council of Nicaea.² The growing power of Christianity most likely contributed to the elimination of tattooing in the West,

although many soldiers who fought in the Crusades received tattoos during their travels.³

Despite the long history of tattoos in both the East and West, Captain James Cook often is credited with discovering tattooing in the eighteenth century during his explorations in the Pacific.⁴ In Tahiti in 1769 and Hawaii in 1778, Cook encountered heavily tattooed populations who deposited dye into the skin by tapping sharpened instruments.³ These Polynesian tattoos, which were associated with healing and protective powers, often depicted genealogies and were composed of images of lines, stars, geometric designs, animals, and humans. Explorers in Polynesia who came after Cook noted that tattoo designs began to include rifles, cannons, and dates of chief's deaths—an indication of the cultural exchange that occurred between Cook's crew and the natives.³ The first tattooed peoples were displayed in the United States at the Centennial Exhibition in Philadelphia, Pennsylvania, in 1876.² Later, at the 1901 World's Fair in Buffalo, New York, the first full "freak show" emerged, and tattooed "natives" were displayed.⁵ Since they were introduced in the West, tattoos have been associated with an element of the exotic in the United States.

Acknowledged by many to be the first professional tattooist in the United States, Martin Hildebrandt opened his shop in New York City, New York, in 1846.² Initially, only sailors and soldiers were tattooed, which contributed to the concept of the so-called "tattooed serviceman."⁵ However, after the Spanish-American War, tattoos became a fad among the high society in Europe. Tattooing at this time was still performed through the ancient Polynesian tapping method, making it both time-consuming and expensive. Tattoos generally were always placed in a private location, leading to popular speculation at the time about whom in the aristocracy possessed a tattoo, with some even speculating that Queen Victoria

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may have had a tattoo.¹ However, this brief trend among the aristocracy came to an end when Samuel O'Reilly, an American tattoo artist, patented the first electric tattooing machine in 1891.⁶ His invention made tattooing faster, cheaper, and less painful, thereby making tattooing available to a much wider audience. In the United States, men in the military often were tattooed, especially during World Wars I and II, when patriotic themes and tattoos of important women in their lives (eg, the word *Mom*, the name of a sweetheart) became popular.

It is a popular belief that a tattoo renaissance occurred in the United States in the 1970s, sparked by an influx of Indonesian and Asian artistic styles. Today, tattoos are ubiquitous. A 2012 poll showed that 21% of adults in the United States have a tattoo.⁷ There are now 4 main types of tattoos: cosmetic (eg, permanent makeup), traumatic (eg, injury on asphalt), medical (eg, to mark radiation sites), and decorative—either amateur (often done by hand) or professional (done in tattoo parlors with electric tattooing needles).⁸

Laser Tattoo Removal

Today tattoos are easy and relatively cheap to get, and for most people they are not regarded as an important cultural milestone like they were in early Polynesian culture. As a result, dermatologists often may encounter patients seeking to have these permanent designs removed from their skin. Previously, tattoo removal was attempted using destructive processes such as scarification and cryotherapy and generally resulted in poor cosmetics outcomes. Today, lasers are at the forefront of tattoo removal. Traditional lasers use pulse durations in the nanosecond range, with newer generation lasers in the picosecond range delivering much shorter pulse durations, effectively delivering the same level of energy over less time. It is important to select the correct laser for optimal destruction of various tattoo ink colors (Table).^{8,9}

Controversy persists as to whether tattoo pigment destruction by lasers is caused by thermal or acoustic damage.¹⁰ It may be a combination of both, with rapid heating of the particles leading to a local shockwave as the energy collapses.¹¹ The goal of tattoo removal is to create smaller granules of pigment that can be taken up by the patient's lymphatic system. The largest granule that can be taken up by the lymphatic system is 0.4 μm .¹⁰

In laser treatment of any skin condition, the laser energy is delivered in a pulse duration that should be less than the thermal relaxation time of the chromophores (water, melanin, hemoglobin, or tattoo pigment are the main targets within the skin).¹² Most tattoo chromophores are 30 nm to 300 nm, with a thermal relaxation time of less than 10 nanoseconds.^{10,12} As the number of treatments progresses, laser settings should be adjusted for smaller ink particles. Patients should be warned about pain, side effects, and the need for multiple treatments. Common side effects of laser tattoo removal include purpura, pinpoint bleeding, erythema, edema, crusting, and blistering.⁸

After laser treatment, cytoplasmic water in the cell is converted into steam leading to cavitation of the lysosome, which presents as whitening of the skin. The whitening causes optical scatter, thereby preventing immediate retreatment of the area.¹¹ The R20 laser tattoo removal method discussed by Kossida et al,¹³ advises practitioners to wait 20 minutes between treatments to allow the air bubbles from the conversion of water to steam to disappear. Kossida et al¹³ demonstrated more effective removal in tattoos that were treated with this method compared to standard treatment. The recognition that trapped air bubbles delay multiple treatment cycles has led to the experimental use of perfluorodecalin, a fluorocarbon liquid capable of dissolving the air bubbles, for immediate retreatment.¹⁴ By dissolving the trapped air and eliminating the white color, multiple treatments can be completed during 1 session.

Laser Treatment Recommendations For Common Pigments Used in Tattoo Ink^{8,9}

Ink Color	Pigment	Laser Wavelength
Black	Amateur: India ink; professional: carbon, iron oxide	694 nm, 755 nm, 1064 nm
Blue	Cobalt aluminate	694 nm, 755 nm, 1064 nm
Brown	Ochre	532 nm, 694 nm, 755 nm, 1064 nm
Green	Chromium oxide, malachite green	694 nm, 755 nm
Red	Cadmium selenide, mercury sulfide, sienna	532 nm
White	Titanium oxide, zinc oxide	532 nm ^a
Yellow	Cadmium sulfide	532 nm

^aTreatment may cause paradoxical darkening of the tattoo ink.

Risks of Laser Tattoo Removal

It is important to emphasize that there are potential risks associated with laser treatment for tattoo removal, many of which we are only just beginning to understand. Common side effects of laser treatment for tattoo removal include blisters, pain, bleeding, hyperpigmentation, or hypopigmentation; however, there also are rare potential risks. Tattoo ink can paradoxically darken when it contains metals such as titanium or zinc, as often is found in tan or white inks.¹⁵ The laser energy causes a shift of the metal from an oxidized to a reduced state, leading to a darker rather than lighter tattoo upon application of the laser. There also have been documented cases of intraprocedural anaphylaxis, delayed urticaria, as well as generalized eczematous reactions.¹⁶⁻¹⁸ In these cases, the patients had never experienced any allergic symptoms prior to the laser tattoo removal procedure.

Additionally, patients with active allergy to the pigments used in tattoo ink provide a therapeutic dilemma, as laser treatment may potentially systematize the tattoo ink, leading to a more widespread allergic reaction. A case of a generalized eczematous reaction after carbon dioxide laser therapy in a patient with documented tattoo allergy has been reported.¹⁹ More research is needed to fully understand the nature of immediate as well as delayed hypersensitivity reactions associated with laser tattoo removal.

Final Thoughts

With thousands of years of established traditions, it is unlikely that tattooing will go away anytime soon. Fortunately, lasers are providing us with an effective and safe method of removal.

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