Tattoos

Tattoos have been present in the culture of mankind since the beginning of civilization. They are permanent signs on the body that have different meanings: amulets, symbols of status, declarations of love, statements of religious beliefs, adornments, and even sometimes a form of punishment. The first described reports of tattoos date from 2,000 BC, and were found in Egyptian mummies. In 1991 a mummy from the ice age (around 5,200 years old) was found, which had several tattoos on its body. One development during the history of tattoo artistry was the introduction of different colored pigments, allowing more complex tattoos. Attempts to remove tattoos are also very old.

Tattooing involves the placement of pigment into the skin's dermis, the layer of dermal tissue underlying the epidermis. After initial injection, pigment is dispersed throughout a homogenized damaged layer down through the epidermis and upper dermis, in both of which the presence of foreign material activates the immune system's phagocytes to engulf the pigment particles. As healing proceeds, the damaged epidermis flakes away (eliminating surface pigment) while deeper in the skin granulation tissue forms, which is later converted to connective tissue by collagen growth. This mends the upper dermis, where pigment remains trapped within successive generations of macrophages, ultimately concentrating in a layer just below the dermis/epidermis boundary. Its presence there is stable, but in the long term (decades) the pigment tends to migrate deeper into the dermis, accounting for the degraded detail of old tattoos.

Types of Tattoos

Tattoos can be divided into five categories: professional, amateur, cosmetic, medical, and traumatic. The professional type is performed using professional devices that contain vibratory needles, and pigments of various colors. The granules of pigment are deposited superficially in the dermis. Amateur tattoos are performed with needles or improvised devices and pen ink, charcoal, and soot are usually used as pigments. The use of cosmetic tattoos has increased in recent times, especially in eye-brows, eyelids (eyeliner), lip (contour), reconstruction of breast areola tissue and of other scars. Mostly brown, black, pink, and red pigments are used in those cases.

Traumatic tattoos occur when pigment is deposited in the skin through abrasion or resulting from the force of an explosion. The materials (asphalt, gunpowder, etc.) remain housed in the dermis after the trauma, lending a black or bluish hue to the skin,

depending on the depth at which they settle. Medical tattoos are used, for example, in radiotherapy protocols.

Tattoo removal techniques

The oldest tattoo removal techniques date back to 543 BC, having been developed by the Greeks, who performed abrasion followed by the application of salts and chemicals. Dermabrasion has also been widely used. The principle of this technique is based on the local destruction of the skin and the consequent removal of the tattoo's pigment. The use of trichloroacetic acid in high concentrations. These two techniques do not always lead to complete removal of the tattoo and have a high risk of skin depigmentation and unaesthetic scars. Surgical removal of tattoos can also be performed. Nevertheless, linear scars may result from the procedure, and often tattoos are too large or in difficult to access sites.

Surgical removals can be indicated for patients who have allergic reactions to the pigments of tattoos. In such cases, removal attempts using laser can cause hypersensitivity reactions and even anaphylactic shock.

The first report of laser based tattoo removal using QS Nd:YAG laser was published in 1965.

However, the lack of a thorough understanding of the physics of this laser type, combined with unpredictable clinical results, led it to fall into disuse at that time. At the end of the 1970's and in the beginning of the 1980's, the most widely used lasers for tattoo removal were the carbon dioxide (CO_2) and argon types.

Given that these lasers have water as the chromophore and that they are not selective, the problem of inconsistent clinical outcomes, with the possibility of the formation of unaesthetic scars and hypopigmentation arose again.

The argon laser emits blue or green light and has a wavelength of 488 or 514 nm. Early in the 1980's there was great progress following the publication of the theory of selective photothermolysis.

In this manner, selective Q-switched lasers (QS) would only destroy specific targets, with minimal damage to the underlying tissue. The theory previously proposed by Goldman was put into practice, inaugurating the use of QS Ruby laser for removing tattoos.

Devices with pulses in the magnitude of milliseconds, such as those employing intense pulsed light, should not be used for tattoo removal, for they heat the granules of the pigment, allowing that heat to spread to adjacent tissue, causing damage. Attempts at removing tattoos with these devices usually results in scarring and does not completely remove the pigment. For best results Q-switched lasers must be used.

Q-Switched Laser

In a study of tattoos treated with the use of QS lasers, the destruction of pigment contained in the cells, with the fragmentation of target-pigments, can be observed.

That pigment is then phagocytised, and an inflammatory response is responsible for transporting those cells into the lymphatic tissue. QS Ruby laser was the first QS laser to become commercially available, followed next by the QS Nd:YAG and QS Alexandrite lasers. These three lasers are still currently used—and it is important to note that each has a different wavelength. In order to select the correct laser to be used, the following criteria must be considered: the patient's skin phototype, laser pulse duration, spot size, and fluence.

QS Ruby lasers have a wavelength of 694nm, emit red light, and are better absorbed by the black and dark blue colors. Very dark and amateur tattoos usually respond considerably well to this laser type. Medical tattoos can also have a good response. After treatment with this laser type, transient hypopigmentation that resolves spontaneously in variable periods can occur.

Study carried out with 47 black or blue tattoos treated simultaneously with QS Ruby, QS Nd:YAG and QS Alexandrite lasers, with QS Ruby showing superior results. The QS Ruby laser is effective in treating green ink, although QS Alexandrite treats this color more efficiently.

QS Nd:YAG laser has a wavelength of 1,064 nm, emits green light and, through the KTP crystal (potassium titanyl phosphate), also doubles the 1,064 frequency, emitting a 532nm wavelength. This versatility allows for the treatment of dark pigments (such as black and dark blue) using 1,064nm; red, yellow, and orange pigments can also be treated with 532nm.

The longer wavelength lends greater penetrating power to this type of laser, thus better protecting the melanocytes of the epidermis, and as a result it is a laser type suitable for higher skin phototypes. Some studies comparing QS Ruby with QS

Nd:YAG have demonstrated that the latter has less tendency to cause blisters and less chance of residual hypopigmentation

Generally, darker and amateur tattoos respond well to all three types of lasers mentioned above, for, by definition, the black color absorbs the wavelengths of all visible light. Red and green pigments are well absorbed by 532nm QS Nd:YAG and 755nm QS Alexandrite, respectively. However, modern tattoos are often composed of a mixture of colors that can be complex and highly variable, with very similar colors even having completely different compositions, and thus very different absorption spectra. The variation in chemical composition and absorption spectrum can result in tattoos that are resistant and even unresponsive to laser treatment.

Colors such as yellow and orange are known to be very resistant, and colors such as red and green have a highly variable response. The tattoos treated contained white, yellow, and shades of red pigments, becoming gray or completely dark after the sessions.

The exact mechanism that explains this change in color is not known. Cosmetic tattoos in shades of red and brown usually contain iron oxide in their composition and the oxidation of this component following QS Ruby laser sessions has already been demonstrated in vitro.

Considerations regarding the treatment

The patient must be informed about the number of sessions required to remove the tattoo (six to ten, or possibly more sessions) and about the possibility of their incomplete removal. The number of sessions depends on the tattoo's color, and the age and depth of the pigment.

It is important to instruct patients about protection against the sun—since melanin absorbs the laser and therefore there is a greater chance of damage to adjacent skin, with blistering, hypopigmentation, and scarring. If the patient is tanned or has a higher phototype, 1,064nm QS Nd:YAG is recommended, for it has a greater protective effect of epidermal melanocytes, due to the longer wavelength.

It is also important to pay close attention to the spot size of the device used in the treatment the larger the spot size, the less energy will be deposited superficially in the skin and the lower the chance of causing damage to epidermal melanocytes. In patients with higher photo types or who are tanned, skin-whitening treatment is

recommended before the sessions. These treatments can be carried out with creams containing tretinoin, hydroquinone, and corticosteroids (triple combination).

Anesthesia before the sessions is indicated, with the possible use of topical anesthetics in the form of creams with 5% lidocaine, with occlusion before the session or use of infiltrative and even regional block anesthesia. Cooled air can be used during the session to provide comfort. When the tattoo is considerably large, it is recommended that it be divided into parts, treating one part per session.

The color of the tattoo and the patient's phototype will be the main criteria in selecting the laser type to be used. As already indicated, QS Ruby, (1,064nm) QS Nd:YAG and QS Alexandrite are the most effective lasers in the treatment of dark blue and black tattoos. The carbon contained in the pigment of amateur tattoos also responds well, typically requiring fewer treatments than colored professional tattoos. However, in patients with higher phototypes,1.064nm QS Nd:YAG laser is indicated, as the longer wavelength interacts less with the epidermal melanin, resulting in a lower probability of hypopigmentation.

Colorful tattoos have unpredictable responses to treatment. In general, QS lasers will treat most of the colors, even though certain colors may be highly resistant to treatment (particularly yellow and orange).

Some lasers can treat certain colors more effectively—as 532nm QS Nd:YAG and QS Alexandrite lasers for red and green pigments, respectively—but as tattoo pigments are complex compounds with varying compositions, the successful treatment of colorful tattoos is often difficult. As the response of a tattoo to laser cannot be predicted, a test point can be indicated at the physician's discretion before the full treatment.

During the session, the laser will cause the "whitening out" of the color in the treated area. This phenomenon seems to be attributed to the vapor and gas bubbles resulting from the fast heating of the tissue, which usually resolves 20 minutes after the session.