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Review Article

Tattoo removal methods: A review

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Abstract Tattoos have existed since ancient times in every culture with a growing fascination. The need for tattoo removal has also increased in demand with its rising popularity. After an extensive literature review, we have outlined the various conventional tattoo removal methods that have existed and continue to be practiced and the theory behind it, new laser devices and the various strategies that have been applied for effective tattoo removal and also the surgical methods which are employed. Although tattoo removal methods have revolutionized over time, further research is needed to offer safer and more effective methods.

Key words
Tattoo removal, non laser techniques, laser techniques, surgical techniques.

Introduction

Tattoos have been a fascination for generations amongst mankind from all cultures and socio-economic strata. From ancient times, tattooing has been used to enhance the beauty, represent uniqueness, declare belonging and even as an identification or even to shame and punish people. For thousands of years, tattooing remained a slow and painful process wherein each puncture on the skin was performed manually by hand.[1] The invention of electric tattooing machine, in the late 1800's revolutionized the art of tattooing. Thus, tattooing became more accessible and affordable, and in a survey done by The Harris Poll in 2015, they found that 29% of adults in USA sport at least one tattoo, which was an increase by 8% from 4 years earlier.[2] Although many are happy with their tattoos, surveys have shown that these tattoos are sometimes obtained as a result of impulsiveness, under the age of 18 years or under the influence of drugs and alcohol.[3] Therefore many usually regret their decision of having a tattoo as a result of embarrassment, decreased self-esteem and stigmatization due to their tattoos and ultimately seek removal of the same.[4,5]

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Methods of tattoo removal

The tattoo removal methods can be broadly classified into:

1. Non- Laser techniques

Cosmetic camouflage

Cosmetic camouflage products are available as liquids, creams and powders. Cosmetic camouflage differs from regular cosmetic products as they have a higher concentration of pigments and last longer and are more opaque and thicker than regular foundation makeup. When camouflaging tattoos, the principles of complement color theory must be applied to achieve better results.

Tattoo supplementation[6]

Tattoo supplementation is a technique of

Figure 1 Over-tattooing.

Figure 2 Over-tattooing.

modifying or rectifying a tattoo by additionally tattooing over the objectionable part of the tattoo.

Over-tattooing[7]

Over- tattooing is a technique where tattooing is done over the existing design either to modify its appearance completely or reduce its visibility by using lighter pigments **(Figure 1-2)**.

Salabrasion[8-10]

Salabrasion is a method of tattoo removal where the skin is superficially abraded with table salt to deliver the sodium chloride to the underlying dermis. Boo-Chai reported that an inflammatory response secondary to superficial dermabrasion results in increased biological removal of the pigment via the lymphatics and sloughing off of macrophages.[11] Clabaugh postulated that treatment of tattoos with salt enhances the phagocytic activity and the pigment laden macrophages become mobile move towards the wound surface where they are removed by daily change in the dressing.[12] The area to be treated is shaved and prepared. The tattoo is rubbed by the patient himself or with the use of a device resembling door knob until skin becomes blood red and appears like granulation tissue which may usually take 30-40 minutes. The treated area is then covered with an antibiotic ointment and a sterile dressing is placed. On post-operative day 3 the treated area is dry and looks like tanned leather. The eschar separates by 7or 12 post- operative days and half the tattoo ink is removed with it. Remaining ink leaves the treated area in the exudate while skin healing takes place. The skin heals rapidly without scarring and a second session if required can be done 6-8 weeks after the first session.

Chemical tattoo removal[13,14]

A variety of chemicals such as trichloroacetic acid, tannic acid, phenol, sulphuric acid, nitric acid, salicylic acid, silver nitrate etc. are used either or in combination with other techniques to treat the tattooed areas. In their first application, these chemicals produce an inflammatory response in the form of mild erythema or intense burn resulting in the formation of an eschar. Most of the pigments come out along with the eschar as it separates. In second and third sessions these chemicals produce a full thickness burn of the skin with a prolonged healing time. This results in the formation of a moist eschar with secondary infection which is required for removal of pigments in the deeper dermis.

Recently, 0.1% Ingenolmebutate, a topical therapeutic drug used in the treatment of actinic keratosis has shown to remove 2 week old tattoos from hairless mice effectively. The mice were treated once daily for two days, following which eschar development began and was completely formed at day 8. By day 20 the eschar was shed off and no visible tattoo was seen, as the tattooed site continued to heal.[15]

Dermabrasion[12,16-19]

Use of wire brush or diamond fraises for dermabrasion is one of the most common and simple procedures performed that is associated with satisfactory results. Superficial dermabrasion is carried out till pinpoint bleeding and the tattoo are seen. A dressing is applied which is changed everyday which takes a part of the pigment with it in every change. Repeated procedures may be required as it is often associated with incomplete removal of pigment. Therapeutic spot dermabrasion and layered dermabrasion are techniques where the tattooed area is abraded till pinpoint bleeding is observed and further abraded till majority of the tattoo pigment is removed as much as possible. The surrounding border is then superficially abraded to feather into the normal skin around it. This method is very effective as the tattoos disappear and also their features get obscured by the surrounding healed skin.

Radiosurgery[20]

This technique involves the transmission of electromagnetic waves via an electrode to produce vibrations of molecules in the tissue of contact. The adjacent tissues not in contact with the electrodes remain less harmed as only the tissue in contact is ablated. A local anesthetic cream is applied at least an hour prior to the procedure and a ball shaped electrode is used for coagulating the tattoo. The treated area forms a scab and falls off in 5-7 days. Lesions usually tend to heal with scarring and post inflammatory hypo or hyperpigmentation and may require repeated sessions for complete removal of pigment.

Cryotherapy[21-24]

Cryotherapy is one the low cost and easily available method for tattoo removal. Freezing results in blister formation with separation of epidermis from the dermis. The blister fluid removes the intradermal pigment molecules and deranges the dermo- epidermal junction which permits transepidermal elimination of the pigment molecules. The same mechanism is repeated in multiple session of cryotherapy which results in fading of the tattoo.

Infrared Coagulator [25-29]

It was first developed in 1975 and approved by the US FDA in 1991 for tattoo removal. It emits a non-coherent radiation which leads to non-specific thermal effects. The coagulator consists of a hand piece which is connected to the main electrical supply using a transformer, a bulb which emits light between 400-2700nm with maximum emission between 900-960nm, a gold plated reflector which reflects the radiation down a rigid quartz light guide. The light guide comes with a sapphire cap measuring 6 mm which is applied to the skin. It also has an electronic timer with which the operator can choose pulse duration between 0 and 1.5s. Although it is a simple, quick and cheap method of tattoo removal, it results in non-specific tissue damage and scarring.

Innovative Non- laser tattoo removal[30,31]

It is a new and innovative technique that has recently emerged which works on the principle of wound healing, where a pigment containing scab is formed after the procedure which eventually falls off, thus eliminating the tattoo ink. A patented solution containing distilled water and L40 lactic compound is injected using a micro- pigmentation machine with a minimum depth of 1mm. Even though it's cheaper than the laser tattoo removal, scarring and texture changes are the common side effects with this method.

Table 1

Tattoo ink color	*Optimal treatment wavelength (nm)*
Black	694; 755; 1064
Green	694; 755
Blue	694; 755; 1064
Red	532
Orange	532
Yellow	532
Purple	694; 755
Tan/ nude/ white	10,600

II. Laser techniques

The QS ruby laser (694nm) was the first commercially available QS laser for tattoo removal in 1983,[32] followed by the QS Nd: YAG laser (532nm, 1064nm) and the QS alexandrite laser (755nm) are the traditional workhorses for tattoo removal. Newer strategies using combination laser treatments, multi-pass treatments and picosecond lasers offer promising results. The tattoo color and skin type of the patient are important considerations when choosing the appropriate laser.

Certain wavelengths have proven more effective at removing different colors **(Table 1)**.

Blue or black tattoos

Darkly pigmented black or blue tattoos can be effectively treated by QS ruby, QS Nd:YAG (1064 nm) or QS alexandrite laser.[33,34] In darker skin types where there is heavy epidermal melanin content, QS Nd:YAG laser is the laser of choice to reduce the risks of postinflammatory hyper- and hypopigmentation post tattoo removal **(Figure 3 and 4)**.[35]

Red tattoos

The light emitted from the 1064nm QS Nd:YAG laser may be doubled in frequency to produce light with a wavelength of 532 nm. Red, orange, and red-brown pigments respond well to this wavelength.[34,36]

Figure 3 Amateur tattoo before.

Figure 4 Amateur tattoo after 6 sessions of QS Nd:YAG.

Studies comparing the QS 532nm Nd:YAG have also found it to be superior to the QS ruby and QS 1064 nm Nd:YAG in the removal of red colors in professional tattoos.[37,38]

Green tattoos

Both the QS alexandrite and QS ruby laser are effective for the treatment of green tattoos, although the QS alexandrite laser is considered the modality of choice.[34,36] In addition to black, blue, and green tattoos, QS Ruby also works well for purple and violet pigments.[34]

Light colored tattoos

Cosmetic tattoos or pale-colored tattoos can be more difficult to treat as they often contain red, brown, flesh-colored, and white inks containing iron oxides and titanium dioxide, which may irreversibly turn black after QS laser irradiation due to chemical reduction of ferric to ferrous oxide.[39] Such paradoxical darkening has been successfully treated with further QS laser treatments, sometimes requiring up to 20 sessions.[40,41] Ablative laser resurfacing with pulsed CO and erbium-doped YAG lasers have also been successfully used in cosmetic tattoos.[42,43]

Figure 5 Bindi tattoo before procedure.

Figure 6 Bindi tattoo after 2 sessions of Picolaser.

Figure 7 Cosmetic tattoo before procedure.

Figure 8 Cosmetic tattoo after 3 session with QS Nd:YAG.

Figure 9 Unresponsive cosmetic tattoo after 3 sessions of Picolaser.

New trends in laser tattoo removal

Picosecond lasers

In recent times, the pico second pulse duration lasers (ps-lasers) have emerged as the new modality for laser tattoo removal with many clinical trials reporting it safety and efficacy in the management of multicolored and resistant tattoos.[44-48]

The ps- lasers are considered to be superior as they produce significant mechanical stress in the target and minimal thermal effect when compared to the ns- lasers. Due to its shorter pulse duration, there is an efficient tattoo removal due to the exertion of photoacoustic effects. The ps-lasers are highly specific to the target with lesser dissemination of heat to the surrounding tissues thus resulting in fewer side effects.[7] In this article we present cases treated by ps-laser **(Figure 3-9)**.

Combined laser treatment

Animal models with cosmetic tattoos treated with non-ablative and ablative fractional lasers have demonstrated tattoo pigments in the microscopic coagulation zones migrating to the epidermis and becoming part of the microscopic exudative necrotic debris that can be exfoliated after 5 days.[49,50] Such fractional resurfacing can be combined with the traditional QS lasers for a synergistic effect **(Figure 10-11)**.

Figure 10 Amateur tattoo before.

Figure 11 Amateur tattoo after 4 sessions of treatment with combination of CO_2 and QS Nd:YAG.

Figure 12 Amateur tattoo before.

Figure 13 Amateur tattoo after 2 sessions of treatment with QS Nd:YAG following R20 method.

Multiple pass treatment

The R20 method of tattoo removal was first described by Kossida *et al*. where accelerated lightening can be achieved by using four laser passes in one treatment session, with an interval of 20 min between each pass.[51] Before the second pass is given, 20 minutes of cooling time is provided to allow resolution of post laser immediate whitening. It is hypothesized that repeated passes ensure removal of pigment in successive deeper layers of dermis **(Figure 12-13)**.

R0 method involves application of topical perfluorodecalin which reduces whitening reaction immediately thus allowing for repeated passes without having to wait for 20 minutes between passes.[52]

Microencapsulated ink

These ink consist of microencapsulated dyes in polymethylmethacrylate beads. The encapsulated shell can be targeted instead of disrupting the entire pigment particle. Studies in hairless rats and guinea pigs showed significantly increased ease of removal.[53]

III. Surgical techniques[54]

Although rare, surgical methods are still employed for management of tattoos. For very tiny tattoos, punch excision and closure can be done. Smaller tattoos can be managed by simple excision and closure techniques leaving a small scar. Flap surgeries can be employed based on the geometries of the tattoos. O to Z flaps for round tattoos and rotation flaps for elongated tattoos may be considered. Blepharoplasty is useful in tattoos involving the eyelids. Split thickness tangential excision and serial split thickness excision can facilitate removal of larger tattoos on limbs and trunk.

Conclusion

As the trend for getting a tattoo increases, the demand for tattoo removal will equally increase. Laser treatment continues to be the gold standard for safe and effective removal of unwanted tattoos. Recent advances have led to improved clinical outcomes with fewer treatment sessions. Continued research is necessary to further enhance the technology to

enhance the speed of the treatment process and reduce its associated cost.

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