



# Medical applications of tattooing

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**Abstract** Tattooing is an ancient procedure, practiced by humans from all parts of the world for a variety of reasons. However, relatively little is known by the medical audience of the numerous medical conditions where tattooing is employed as a therapeutic modality or a diagnostic method. Tattooing for cosmetic and medicinal purposes, referred to as either micropigmentation, dermatography, or medical tattooing, may ensure permanent camouflage in a wide range of dermatological diseases. It can be a valuable finishing step in several surgical procedures in the fields of craniofacial surgery, plastic and reconstructive operations, cosmetic surgery procedures, and breast reconstruction. Other fields of application of medical tattooing include radiation therapy, endoscopic surgery, and ophthalmology.

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## Introduction

Tattooing implies the process of implantation of exogenous colorfast pigments into the skin or mucous membranes leading to a discoloration referred to as a tattoo. In this process, only pigment particles introduced through the skin surface, below the dermal-epidermal junction, are retained by the dermal macrophages and fibroblasts where they reside permanently, producing an indelible change of the skin color under the form of a recognizable pattern or design.

The practice of tattooing has been in existence for thousands of years, with origins tracing back to the Stone Age.<sup>1</sup> Throughout history, the core characteristic of tattoos, their indelibility, has been used by humans from all parts of the world for a variety of reasons, including decoration, to ensure uniqueness in the self-appearance, to mark a status, or

to inflict punishment. Some tattoos are performed to enhance physical beauty, for example, to camouflage pathological skin changes.

The importance and meaning of tattooing have changed according to time periods. For many years, ornamental tattooing has been popular not only among seamen and the military but also among criminals.<sup>2</sup> The prevailing view on tattooing from the 1950s could not be better represented than the statement by the author Hugh Garner who wrote:

Among all the forms of mass masochism practiced by that frailty known as man, none is quite as silly as the acquiring of tattoos. This egocentric perversion has had its devotees since the dawn of time, and in inverted sequence, it has been a tribal custom, penal stigma, class craze, snobbish adornment, and finally a vulgar affectation. Among the Maoris and various Hindu sects it is still a mark of caste and beauty, but among most Western peoples, it is at best a juvenile indiscretion, and at worst a thing of shame and loathing to those of us who are tattooed. It can, and does, slow a person's social life to a crawl.

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During the past several decades, however, the public perception of tattooing has greatly evolved. In both the European continent and in the Americas, tattoos and other types of body art, such as piercing, have dramatically increased in popularity, especially among adolescents and young adults.<sup>3</sup>

With all of its prerequisites, tattooing has frequently attracted a great deal of scientific curiosity. From the medical perspective, it is an invasive procedure involving several components that might be potentially hazardous and may threaten the health of the tattooed individual. The unequivocal risk of transmission of several blood-borne and infectious diseases by tattooing has been shown and is a source of unabating public health concern.<sup>3</sup> The demographic, psychological, and behavioral aspects of the tattooed have been the focus of extensive research in the mental health field.<sup>4,5</sup> As far as dermatologists are concerned, most patients are seeking help in relation to tattoos, either to have them removed or for treating the diverse cutaneous complications reported as a consequence of permanent and temporary tattooing.

Relatively little is known by the medical audience of the numerous special conditions where tattooing is employed as a therapeutic modality or a diagnostic method. Examples of such medical applications are endoscopic tattooing, corneal tattooing, as well as the recently introduced treatment of viral warts by means of tattooed cytostatic drugs.

## Historical aspects of medical tattooing

Perhaps the history of medical tattooing is as old as the history of ornamental tattooing. Speculation surrounds the tattoo marks seen on the naturally preserved human body from 3300 BCE found in a snowfield in the Tyrolean Alps, near the natural pass called the Hauslabjoch.<sup>6</sup> These tattoos, in the form of groups of small parallel lines, were located over the lumbar spine, the right knee, and both ankles of the corpse. Because radiographic studies revealed that the man from Hauslabjoch had osteoarthritis in these joints, it was suggested that the tattoos might indicate a form of stimulatory treatment similar to acupuncture. Other well-preserved prehistoric mummies found in Siberia and Peru had both ornamental and nonornamental tattoos. The difference in the tattoos was so obvious that a possible therapeutic importance was attributed to the ones of less aesthetic value.<sup>1</sup>

Tattoos have been seen on Egyptian mummies dating from about 2000 BCE.<sup>7</sup> In the Bible, Moses warned the Jews against the use of tattooing.<sup>8</sup> Although in ancient Greece decorative tattooing was considered as barbaric, a crude way of medical tattooing was practiced in 150 CE by Galen, who attempted to cover leukomatous opacities of the cornea by cauterizing the surface with a heated stilet and applying powdered nutgalls and iron (ferric tannate) or pulverized pomegranate bark mixed with copper salt.<sup>9</sup> The Romans used tattooing and

branding with a hot iron to mark prisoners of war, captives, and criminals.<sup>10</sup> At the same time, a class of physicians was maintained who specialized in the removal of these marks from the skin of successful gladiators and slaves who were granted their freedom.

Interest in tattooing declined with the advent of Christianity. It was banned by a papal edict in 787 CE.<sup>11</sup> In the Middle Ages, it was used essentially for marking criminals, a procedure also practiced in the British Army on deserters.<sup>10</sup> Although tattooing was forbidden in Europe, it persisted in the Middle East and in other parts of the world, reaching the highest form of art in the islands of the South Pacific and in Japan.<sup>11</sup>

During the Age of Exploration, tattooing was reinstated in Europe, possibly as a result of James Cook's expedition, which brought the old continent into contact with the many cultures practicing tattooing. Tattooed Indians and Polynesians, and later Europeans tattooed abroad, attracted much interest at exhibits, fairs, and circuses in Europe and the United States during the 18th and 19th centuries. Influenced by Polynesians and Japanese examples, tattooing "parlors" were mounted in port cities all over the world where specialized "professors" applied decorative designs on European and American sailors.<sup>11</sup>

By the mid 1800s, the first papers to document unequivocally medical application of tattooing appeared. In 1835,<sup>12</sup> a German physician, Pauli, employed tattooing with mercury sulfide and white lead for the restoration of the natural color to the skin in cases of congenital vascular nevi. In 1850, Shule<sup>13</sup> recommended cosmetic tattooing with mercury sulfide after plastic lip procedures. In the 1870s,<sup>14</sup> the oculoplastic surgeon Louis Von Wecker put into practice the modern method of corneal tattooing of unsightly corneal scars, which became largely used during the subsequent decades to improve the cosmetic appearance of the "blind eye." At this time, the pigments used were mainly confined to black powdered charcoal or india ink; red-colored mercury sulfide, also known as cinnabar or vermilion; and green, obtained from chromium salts.<sup>7</sup> Until 1891, when the first electric tattoo machine was patented, tattooing was performed by hand, using a single needle or instruments with varying needles configurations. The procedure was long and tedious.

By 1900, several social events catalyzed the development of both plastic and aesthetic surgery, regarded at this time as the "serious" and "frivolous" counterparts of what we today know as one and the same specialty: using surgery to improve function and normal appearance at the same time. Feminist movements and socialization of women into a "beauty" culture, along with the relative prosperity and the industrial revolution of the early 20th century, led to the formation of a consumer society that favored the introduction of new aesthetic surgical procedures, such as rhinoplasty, otoplasty, and blepharoplasty, in which tattooing found a place.

In 1911, Frederick S. Kollé,<sup>15</sup> a German surgeon practicing in New York, used tattooing with cinnabar to

outline the border of scarred lips; in the 1920s, tattooing of the eyelids was applied to simulate sparse or missing eyelashes after ocular surgery.<sup>16</sup> Not until the post World War I period did the specialty of plastic surgery emerge. The horrifying wounds from the trenches stimulated the undertaking of various flap- and graft-associated reconstructive procedures that also needed tattooing to simulate a missing lip or absent eyebrows. In 1944, Louis Byars,<sup>17</sup> a plastic surgeon at the Washington University in St. Louis, Mo, presented before the annual meeting of the Southern Surgical Association the results from postoperative tattooing undertaken in over 60 cases for the purpose of matching skin grafts and flaps to adjacent facial tissues.

Some rather strange uses were in vogue during the late 1930s and the 1940s. Based on an interesting observation reported in 1909 by Sh. Dohi,<sup>18</sup> a dermatologist from Japan, cutaneous syphilis did not involve portions of skin that had been tattooed red with cinnabar (HgS, mercury sulfide, hydrargyrum sulfuratum rubrum); thus, the treatment of chronic localized pruritic cutaneous lesions by tattooing was recommended. Because the mercurials are antiseptics as well as spirocheticidal, tattooing of the perianal skin with mercuric sulfide was successfully employed in cases of intractable pruritus ani.<sup>19,20</sup> This idea was extended to treat severe itching of the vulva and the scrotum.

By mid century, medical tattooing found a place in the treatment of port-wine stains (PWS) and leukomatous corneal lesions. In 1958,<sup>21</sup> tattooing of the colonic mucosa was employed as a novel method to mark the site of excised colorectal polyps and became a landmark in the field of endoscopic tattooing. By 1974,<sup>22</sup> tattooing was initiated as an adjunct to the reconstruction of the nipple and areola in the burn patient, a method that was further refined in breast surgery. In 1984,<sup>23</sup> Giora Angres perfected tattooing of the eyelids to produce permanent eyeliner, and thus is the beginning of cosmetic makeup.

A variety of machines are available along with a number of pigment manufacturers, but the principles of introducing pigment under the surface of the skin remain the same. Two terms, *micropigmentation* and *dermatography*, were introduced in the medical literature to convey the use of tattooing for medical purposes. Although micropigmentation is the term adopted in the American literature and evokes the use of tattooing for cosmetic reasons and permanent makeup,<sup>24</sup> dermatography designates the method introduced by European authors to designate the art of tattooing applied to permanently correct various cosmetically disabling disorders.<sup>25</sup>

## Cosmetic tattooing/Micropigmentation

Cosmetic tattooing is the art of improving the appearance of eyelids, augmentation or replacement of eyebrows, and improvement of lip contour after trauma or

surgery. Other potential fields of micropigmentation surgery include permanent eye lining, eyelash enhancement for sparse lashes, and nipple replacement by tattooing.<sup>26</sup> Various types of tattooing equipment are available for such treatment by aesthetic dermatologists: for example, Cooper Vision (Natural Eyes); Penmark, Dioptics (Accents); Vision Concepts (Glamour Eyes); Cosmedyne, Alltek, and Eyelite.

Eyelid tattooing is achieved by a single-pronged<sup>23</sup> or triple-pronged<sup>27</sup> needle coated with ferrous oxide pigment, moving rapidly in a reciprocating fashion. Before the surgery, local anesthesia is first applied by subconjunctival injection of 2% lidocaine with 1:100,000 epinephrine. Under a microscope or wide-field magnifying loupes ( $\times 6$  magnifying loupes), the operator implants the pigment at the base of the eyelashes and between the lashes in dot-like fashion, from lateral to medial canthus. The dots are applied sequentially so that they barely overlap, which provides a subtle, fine line of pigmentation. It is recommended that both lower eyelids be tattooed first. In the upper eyelids a heavier line may be obtained by pigmenting two or more rows of dots that should be confluent, with the outer edges of each dot overlapping.<sup>27</sup> After completing the blepharopigmentation procedure, the eyelids are cleaned of excess pigment, and steroid antibiotic ointment is applied to the eyelashes; artificial tears should be used during the next 48 hours to lubricate the eyes to prevent any keratitis from eyelid akinesia. Evaluation of the final result is made at least 1 month after the initial application of pigment. Although initially developed to satisfy the need of handicapped women who wished to have the eyes permanently enhanced, subsequently, eyelid tattooing or blepharopigmentation quickly gained popularity in cosmetic medicine as permanent makeup among the general population. Blepharopigmentation is a particularly convenient cosmetic procedure for contact lens wearers as well as people with presbyopia. Women allergic to conventional eye makeup have also undergone blepharopigmentation.<sup>27</sup> Complications related to this procedure are mostly reported in the ophthalmology literature, including long-lasting pigment spreading, eyelid margin necrosis, cilia loss and secondary cicatricial entropion, preceptal cellulitis.<sup>28</sup> Most commonly, these appear to be caused by improper technique. To avoid ocular injury, a protective shield is advised.<sup>27,28</sup>

The lip liner or full lip color can be done using micropigmentation to change the size and shape of the lips as well as to deepen their color.<sup>29</sup> It is a simpler and permanent technique than collagen implants for the creation of French lips. Lip lining is done in a step-by-step manner to achieve the desired effect according to the individual's choice.<sup>26</sup> Many patients need permanent lip tattooing as a final step in lip rejuvenation surgeries, such as lip advancement and lip-lift, resurfacing, and autologous fat augmentation. Red dye is tattooed into the lip mucosa and over the vermilion border to advance the red color

over the lips onto the glabrous skin.<sup>30</sup> Rare complications have been described with this procedure, such as contact dermatitis to pigment ingredients,<sup>31,32</sup> contact granulomas, pseudoepitheliomatous hyperplasia,<sup>33</sup> and a case of sarcoidosis.<sup>34</sup>

The eyebrows coloring aims to give the appearance of hair in the browline and more fullness for sparse eyebrows or creating an artificial brow when the hair is absent, as in alopecia.<sup>29</sup> A common problem in this procedure is fading of the tattoo pigment or spontaneous change of the dark brown color to a reddish hue over time. The latter process might be explained by the slow change of black-colored ferrous oxide (FeO) to a brown-red ferric oxide (Fe<sub>2</sub>O<sub>3</sub>), which takes place in the skin. Some tattoo inks may show immediate darkening when they are treated with short-pulsed lasers. This complication occurs with the Q-switched ruby, neodymium, and pulse green dye lasers and is explained by the reduction of rust-colored ferric oxide to ferrous oxide.

Although the technique of permanent makeup is fairly simple, it can give satisfactory results only in experienced hands and necessitates close observation and simple precautions. The proper selection of cases is mandatory, and the dermatologists, beauticians, or cosmetic tattooists should be aware of the potential complications. A previous history of Koebnerizing skin disorder, allergies to makeup products or to other substances, and skin infections (herpes simplex) should be carefully collected before planning the procedure.<sup>24</sup>

## Dermatography/Application of tattooing techniques in dermatology

In 1984, Van der Velden, a dermatologist from The Netherlands, began to adapt the classic Japanese tattooing techniques for application in a range of medical disciplines.<sup>25</sup> The techniques that were developed have been termed “dermatography” in the 1990s. Traditional Japanese tattoos from the beginning of the 17th century are closely akin to the Japanese woodblock prints in design, coloring, and techniques.

The tattooing procedure in dermatography consists of implantation of different colors through several consecutive sessions until complete matching of the color of the surrounding skin is obtained. In most cases, the skin is not completely covered by the pigment, but a raster of punctures is created similar to pointillism in Impressionist painting. This allows the underlying skin color to shine through the tattooed pigments, as well as to follow seasonal variations.

Briefly, the technique is performed by means of a modified tattooing machine (a Van der Velden Dermainjector) provided with a needle holder moving up and down in a stainless steel tube with a speed that can be adjusted between

**Table 1** Indications for dermatography as a primary and adjuvant treatment

Primary treatment
Alopecia areata
Areola- and mammillary reconstruction
Depigmentation and hyperpigmentation
Eyebrow reconstruction
Endoscopic marking of colon tumors
External marking of endoprostheses
Hemangioma
Hypertrophic and atrophic scars
Keloid formation
Klippel-Trenaunay-Weber syndrome
Pseudo hair formation
Scar corrections
Tattoo removal with penta-monogalloyl-glucose
Trichotillomania
Verrucae vulgares
Vitiligo
Xanthelasmata
Adjuvant treatment
Adamantinoma—cancrum oris
Ameloblastoma
Burns
Cleft lip and palate
Ectodermal dysplasia
Marking for a Bridley bladder pacemaker
Marking of resection areas
Scleroderma
Seathre-Chatzen syndrome
Skin transplants
Sturge-Weber syndrome
Transplants in head and neck
Tumor marking in the mucosa

Van der Velden et al, 2001.<sup>25</sup>

500 and 3500 rpm. Massive entomological needles, 36 mm in length and 0.36 or 0.41 mm in diameter, with a conical tip are used. The number of needles and the distance between the needle tips can be arranged depending on the required color intensity. The color pigments used consist of a mixture of ferric oxides, carbon black, titanium dioxide, and tartrazine. A series of 64 standard colors varying in intensity between 10% and 100% serve as a reference for specific applications and may be mixed to obtain different subtle shades.<sup>35</sup> The pigment suspension is inserted in the skin along the needles by an alternating effect of pressure and suction caused by the up-and-down movement of the needles and skin elasticity. The angle between the skin surface and the needles also varies between 10° and 90°, depending on the shape of the skin surface and intensity of the color wanted. The depth of the punctures is between 0.6 and 2.2 mm. In most cases, local anesthesia is not necessary because of the low speed of the machine and the spread between the needles. Another reason not to use anesthesia is to avoid dilution of the pigments by the local anesthetic, which is one of the major causes of fading of color.

For the last 15 years, dermatography has been applied with excellent results in a wide range of indications, including hyperpigmentation and depigmentation caused by congenital defects, skin diseases, traumata, and after surgical interventions in plastic and reconstructive surgery and craniomaxillofacial surgery (Table 1).<sup>25</sup>

*Port-wine stains* are benign capillary vascular malformations consisting of dilated ectatic blood vessels in the superficial dermis, clinically manifesting with light-pink to deep-red sharply demarcated macules. Despite the recent advances made, it remains difficult to eradicate PWS fully with the current armory of lasers and noncoherent light sources.<sup>36</sup> For patients resistant to the previous treatment, cosmetic camouflage or cosmetic medical tattooing are acceptable solutions to ameliorate the esthetic appearance of PWS, especially those located on the uncovered parts. Tattooing of PWS has been reported in several papers dating from the 1940s to the 1960s.<sup>37-39</sup> Over 20 years, Conway et al<sup>40</sup> treated more than 1000 cases, reporting satisfactory results in 84% of patients (836 of 996 cases), but complications were not infrequent, including irregular intensity of the pigment deposited and formation of small cavernous lesions within the treated areas, which required further surgical excision. Using dermatography,<sup>35</sup> much better results have been obtained in camouflaging PWS on the face and neck, without any early or late complications observed at a follow-up up to 2 years.

*Vitiligo* is the most common depigmenting disorder, which affects 0.5% to 1% of the worldwide population. Although vitiligo is not a physically disabling disease per se, it may be a major psychosocial problem especially in dark-skinned individuals. Patients partially responding or not responding to standard medical treatments are prescribed cosmetic camouflage creams, which, however, have the disadvantage of rubbing-off on areas where there is friction and sweating and need to be applied daily. Permanent tattooing has been introduced in practice to restore a pigmented appearance of lesional skin in localized stable vitiligo.<sup>41</sup> The results from several reported studies showed excellent color matching in cutaneous,<sup>42,43</sup> mucosal,<sup>44</sup> and mucocutaneous vitiligo.<sup>42,45</sup>

*Piebaldism* is an autosomal dominant, congenital, stable leukoderma characterized by a white forelock and vitiligo-like amelanotic macules. Tattooing was successfully used to cover hypomelanotic patches on the knees in an 11-year-old girl with piebaldism.<sup>46</sup>

*Halo nevus* or Sutton nevus was permanently camouflaged by means of tattooing of the depigmented zone followed by electrocauterization of the nevus part.<sup>47</sup>

*Depigmented postburn scars* and *scars after plastic surgery* present a cosmetically displeasing problem, particularly when located on the face and in darker-skinned individuals. Both tattooing techniques of micropigmentation<sup>48</sup> and dermatography<sup>49</sup> have been applied to disguise hypochromic scars.

*Alopecia areata* (AA) is characterized by patchy hair loss developing in otherwise normal skin. The scalp is most often affected, but other sites such as the eyebrows, eyelashes, and the beard area may be involved, making it a disfiguring disease. A number of therapies have been developed based on the concept that AA is an autoimmune disease, but none of them has been proven to be consistently effective. By way of camouflage, many patients feel happier wearing a wig, and tattooing of the eyebrows can be helpful to restore the esthetic appearance of the face. Van der Velden et al<sup>50</sup> applied dermatography to treat 33 patients with AA of the eyebrows. The results obtained were excellent in 30 patients and good in 3 patients. In 1 patient with partial alopecia of the eyebrows, hair regrowth was seen in the treated area, possibly resulting from the hair follicle stimulation by the dermatography treatment.

*Syringomata*, benign appendageal tumors of the intraepidermal eccrine sweat duct, typically presenting as small skin- or tan-colored papules on the lower eyelids in young women, have been successfully treated by means of tattooing followed by Q-switched Alexandrite laser.<sup>51</sup> The surface of the syringoma lesions was first deepithelialized by vaporization with a clear pulse carbon dioxide laser, after which, iontophoresis with black ink was applied, followed by two-three shots of Q-switched alexandrite laser on the tattooed papules. The results showed complete disappearance of most lesions before the first follow-up week without sequelae. With this method, the black ink was used as photosensitizer for targeting the ductal adenomas that allowed the damage to the neighboring normal tissue to be avoided.

## Plastic and maxillofacial surgery

Tattooing may be a valuable finishing step in several surgical procedures in the fields of craniofacial surgery, plastic and reconstructive operations, cosmetic surgery procedures, and in breast reconstruction.<sup>25</sup>

Dermatography was successfully applied for correcting the color mismatch and reducing the scars in patients operated for unilateral and bilateral cleft lip and palate. For correcting the vermilion border, instead of simply drawing a red lip contour, color is inserted in the filtrum, thus creating a natural "countercontour" effect<sup>52</sup>; in the hairy area of the moustache in men, natural hairs can be simulated by insertion of dots of brown-black pigment.<sup>53</sup>

Micropigmentation has been used to disguise the bald areas in patients with residual scalp scars after hair restoration procedures and brow lift surgery.<sup>54</sup> Moderate degree of pigment fading was reported as the only problem, observed within the first 6 weeks after the tattooing procedure.

Tattoo marks are placed on the scalp of patients undergoing scalp reduction surgery for correction of male

pattern baldness; postoperatively, tattoo marks allow subsequent dynamic measuring of the postoperative “stretch-back” and help define the etiology of a potentially enlarging bald spot.<sup>55,56</sup>

Nipple-areola complex (NAC) reconstruction is an integral part of breast reconstruction after mastectomy for breast cancer; no breast is now considered optimal cosmetically without this pigmented complex.<sup>57</sup> Other conditions requiring NAC reconstruction include congenital anomalies (athelia, amastia), posttraumatic or burn deformities, and complications from breast surgery such as reduction mammoplasty.<sup>58</sup> Tattooing is now largely performed as a final step in NAC reconstruction as a simple, very effective, safe, and minimally invasive outpatient procedure.<sup>57-63</sup> Using different shades of color, the tattooed NAC is able to produce a 3-dimensional effect of a projecting nipple when viewed. The areola is tattooed first working around the periphery and then filling the center. The rugae and texture are imitated with a darker pigment, and white spots are interlaced with lighter tones to resemble Montgomery glands in a natural areola. The nipple is made slightly darker, whereafter a highlight and shadows are added to create a “trompe l’oeil” effect. The edge of the areola is blended into the surrounding skin, so as not to give a distinct edge.<sup>61</sup> A modified pigment-gel-suspension technique has been proposed to achieve more natural results by imitating skin translucency and avoiding an opaque “painted” appearance.<sup>59</sup> The shade chosen for the reconstructed areola is darker than the normal one, so that over time, the fading will result in a more appropriate color match.<sup>57,59,63</sup> Matching the color in daylight, the use of a Munsell color chart,<sup>64</sup> as well as objective color assessment using computer software have been recommended to reduce the risk of color mismatch.<sup>63</sup>

Patient satisfaction with NAC tattooing has been reported to be very high. It is the final stage of an often long and difficult rehabilitation process and signals the end of the patient’s illness and disfigurement and return to “normality.”<sup>57,62,63</sup>

## Radiation oncology

In radiation therapy, patient markings are used for target localization to ensure accurate and precise treatment setup. Precise beam alignment, with reproducible and accurate positioning and immobilization of the patient, is required during each day of a fractionated course of radiotherapy, which may last several weeks. Patient positioning is typically achieved by placing a set of dark pigmented tattoos on the patient’s skin at selected points, generally along the treatment axis. Tattooing is commonly performed using a sterile 18- or 19-gauge hypodermic needle dipped in india ink. The resulting marks, known as “localization,” “radiation,” or “positional” tattoos, are small black dots that serve

as visible and reliable localization points during the prescribed treatment course while also serving as a reference point later.<sup>65</sup> Historically, tattoos were also used to localize past treatment ports during cancer recurrences, but the current general practice is to confirm earlier treatment volumes via imaging of bony anatomy in simulation.

Permanent tattoos, especially those in cosmetically sensitive locations may be troubling because they daily remind cancer survivors of their disease and treatments. For example, patients with breast and lung cancer will have post radiotherapy one or more tattoos on their neckline where the marks are easily seen. Semipermanent ink marks<sup>66</sup> and temporary tattooing with pure henna have been proposed as a marking options to increase patients’ comfort.<sup>67</sup>

Tattooing has been applied in the advent of combined planned preoperative irradiation and en bloc surgical resection for epidermoid carcinoma of the tonsillar area and tongue to outline the largest margins of resection before irradiation.<sup>68</sup>

## Endoscopic tattooing

Endoscopic tattooing is a technique where a specific site in the gastrointestinal tract is labeled by an intramural injection of a staining agent for future surgical or endoscopic surveillance. Initially introduced to mark lesions in the colon before surgical resection,<sup>69</sup> endoscopic tattooing is now well recognized as an effective means to enable subsequent endoscopic and surgical localization of various subtle luminal digestive tract lesions, such as flat or small neoplasms, sites of endoscopically removed polyps, diverticula, and arteriovenous malformations.<sup>70</sup> Colorectal tattooing is the preferred method for tumor localization before colorectal laparoscopic resection.<sup>71</sup> Tattooing has been used in the stomach to mark the sites of malignant polyps, to demarcate antrum from body before highly selective vagotomy, and to mark areas of acute gastrointestinal hemorrhage preoperatively.<sup>72,73</sup> In the esophagus, tattooing was used to mark the proximal level of the squamocolumnar junction in patients with Barrett esophagus ensuring a longitudinal follow-up of 36 months.<sup>74</sup> In a patient with pancreas divisum, tattooing of the minor papilla has been performed, allowing its immediate identification for subsequent attempts at endoscopic therapy.<sup>75</sup>

India ink is most commonly used as a staining agent. When appropriately diluted and injected, india ink tattooing is safe and long-lasting.<sup>71</sup> Rare complications associated with injection of india ink, including phlegmonous gastritis, inflammatory pseudotumor, intraabdominal and rectus muscle abscesses, and inflammatory bowel disease, have been attributed to an inflammatory reaction to substances within the ink, the diluent, or to bacterial contamination. Other dyes, such as methylene blue, indigo carmine, lymphazurin, and indocyanine green have shown disappointing results because of short duration of the staining compared to the permanency

of staining produced by india ink.<sup>76</sup> Recently, a sterile and biocompatible suspension containing highly purified, very fine carbon particles (Spot, GI Supply, Camp Hill, Pa) was developed and is commercially marketed specifically for endoscopic tattooing.<sup>77</sup>

## Corneal tattooing

Permanent tattooing of the cornea can be performed for both cosmetic and optical reasons. Although with the current progress of keratoplasty techniques and contact lens manufacturing corneal tattooing has lost its popularity, it may still be a reasonable alternative in high-risk cases of leukoma or leukocoria where corneal transplantation would lead to rejection and graft failure or in eyes without visual potential.<sup>78</sup> In cases of eccentric semitranslucent scars and contact lens intolerance, complaints of visual disability secondary to light scattering and glare can be managed by a corneal tattoo, which converts an annoying nebula into an opaque plaque causing an absolute scotoma.<sup>79</sup> Occasionally, corneal tattooing has been used in seeing eyes to reduce the glare associated with large iridectomies or traumatic iris loss.<sup>80</sup>

The conventional method for corneal tattooing is similar to dermatography techniques, that is, insoluble staining pigments (india ink, iron oxide, titanium dioxide) are imbedded into the corneal stroma by means of multiple punctures or by means of lamellar keratectomy followed by insertion of the pigments into the midstromal place.<sup>81-83</sup> Another method used is chemical dyeing by placing metallic salts (gold chloride, platinum chloride) on the deepitelialized corneal stroma and then chemically reducing them with hydrazine.<sup>80</sup>

## Significance of tattoos in forensic medicine

Tattooing is of considerable medicolegal import. Tattoos last for a lifetime and persist into the postmortem period and may help in the identification of living as well as of dead individuals, particularly when fingerprints or dental records are unavailable.<sup>84</sup> For example, tattoo marks played a decisive role in the famous Tichborne case from the 19th century.<sup>85</sup>

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