Journal of Pigmentary Disorders

Vangipuram et al., Pigmentary Disorders 2016, 3:1
DOI: 10.4172/2376-0427.1000232

Review Article Open Access

Histopathologic Reaction Patterns in Decorative Tattoos

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Rec date: December 29, 2015; **Acc date:** January 5, 2016; **Pub date:** January 11, 2016

Abstract

In recent years, the practice of decorative tattooing has seen rising popularity and increased social acceptance. As newer tattoo inks are developed and utilized, it is expected that the rate of reactions will rise. Thus, dermatologists are more likely to encounter tattoo-related complications. An understanding of the most common histopathologic reaction patterns ideally will result in increased clinical detection of situations requiring additional evaluation, whether it is for an underlying infection, systemic involvement of disease, or to rule out a cutaneous malignancy. This review will describe both the clinical and histopathologic features of pathologic reactions to decorative tattoos. The main histopathologic reactions are divided into six distinct categories: allergic hypersensitivity, granulomatous, interface, pseudolymphomatous, oncologic and infectious.

Keywords: Tattoo pigment; Tattoo reaction; Histopathology

Introduction

Decorative tattoos have been part of human history and culture for thousands of years. In recent years, they have gained increased popularity and social acceptance. Professional tattoos are created as the tattoo artist uses a needle or a tattoo gun to inject pigment of various colors and composition into the dermis to depths of 1-2 mm. Amateur or self-administered tattoos involve injection of exogenous pigments and dyes using a sharp object [1]. There is growing variability of the composition of tattoo ink, and most professional artists utilize a mixture of metallic salts and organic compounds, the majority of which are inert substances [2].

Currently the estimated rate of complications attributable to decorative tattoos is approximately 2 percent [2]. This rate is expected to steadily increase with the introduction of new substances that may be used in the tattooing process [3]. The inoculation of foreign material into the dermis may elicit an immunologic response that is clinically and histopathologically heterogeneous. Both the clinical and histopathologic features of pathologic reactions to decorative tattoos will be reviewed, with greater emphasis on the latter.

In the absence of pathology, microscopic examination of decorative tattoos typically reveals pigment either lying freely within the dermis or within perivascular macrophages [4]. Decorative tattoos demonstrate pigment that is discretely restricted to the upper reticular dermis, whereas traumatic tattoos display pigment extending throughout all levels of the dermis [5]. Regardless of the color of ink, pigment usually appears black with H and E staining [4]. However exceptions to this rule are commonly demonstrated, especially with red or yellow ink [4]. The main histopathologic reactions observed in complications arising from decorative tattoos can be divided into six distinct categories: allergic hypersensitivity, granulomatous, interface, pseudolymphomatous, oncologic and infectious. This categorization is maintained in the following review, which emphasizes the histopathologic features seen in these specific reactions to decorative tattoos (Table 1).

Pigment Color	Ingredients	Significance
Black	Iron Oxide Carbon Logwood	Rarely associated with allergic reaction [1,6]
Red	Cinnabar/ Mercuric Sulfide	Most common color that causes tattoo reactions, especially with use of cinnabar (mercuric sulfide) [1-6].
	Cadmium Red Iron Oxide Naphthol-AS	Mercury causes lichenoid reactions [6].
Yellow	Cadmium Yellow Ochres Curcuma Yellow Chrome Yellow	Cadmium sulfide is a light-sensitive pigment and can elicit a phototoxic reaction [1,6].
		Chromium, aluminum, and chloride cobalt additives can cause allergic reactions [1,6].
Green	Chromic Oxide Lead chromate Phthalocyanine dyes Ferrocyanides+ Ferricyanides	Chromium has been associated with both localized and generalized eczematous reactions [1,6].
Blue	Azure Blue Cobalt Blue Copper phthalocyanine	Most frequently associated with granulomatous reactions [1].

Purple	Manganese ammonium pyrophosphate Aluminum salts	Some pigments are photoreactive and lose their color after prolonged exposure to UV light [6].
	Dioxazine Carbazole	Manganese has been reported to cause granulomatous reaction [1].
White	Lead carbonate Titanium dioxide Barium sulphide Zinc oxide	Titanium dioxide in tattoos has been known to account for the darkening sometimes seen after high-powered laser treatment [1].
UV tattoos	Polymethylmethacrylate (PMMA)	PMNA has been reported to cause granulomatous reactions [7,8].

Table 1: Tattoo pigment compositions and their dermatological significance.

Spongiotic Reactions

Spongiotic reaction patterns usually present early in the course of tattooing, and may be in response to various topically applied agents other than the notoriously implicated p-phenylelediamine. Reactions that appear clinically consistent with acute contact dermatitis may represent responses to tattoo pigment, carrier solution or miscellaneous topically applied products. Reactions to tattoo pigment are commonly described with the use of red ink but are also seen following intradermal inoculation of black pigment [1]. Similar to other causes of eczematous dermatitis, the degree of acanthosis and spongiosis in these reactions is variable and correlates with the underlying chronicity of the cutaneous eruption. Dermal changes are usually nonspecific and unimpressive with variable degrees of inflammatory cells that may include lymphocytes, macrophages, plasma cells and eosinophils (Figure 1) [1].

Granulomatous Reactions

Foreign-body

Since decorative tattoos involve the deposition of exogenous material into the skin, it is not surprising that tattoo pigments may provoke a foreign body type of granulomatous reaction [6]. Although all ink colors can be involved, granulomatous reactions are most commonly seen in response to intradermal inoculation with red pigment; this is histopathologically demonstrated by a collection of epitheliod cells, lymphocytes, and occasional giant cells [6]. Granulomatous reactions have also been reported in 'UV tattoos', which use phosphorescent pigments such as polymethylmethacrylate (PMMA) to produce a 'glow-in-the-dark' effect [7,8]. Patients present clinically with firm, indurated papules and plaques typically limited to the tattooed areas [2]. The clinical history, together with the presence of granules and pigment on microscopic examination, are often helpful for correct diagnosis [2]. In the appropriate clinical situation, it is essential to exclude a mycobacterial infection using histochemical stains for acid-fast bacilli and tissue culture [9-13]. There are reports of cutaneous tuberculosis developing after jailhouse tattooing and in communities with high disease prevalence [9-12]. Furthermore, Leprosy as a result of tattoo inoculation has also been documented in endemic regions [11-13]. Clinically these patients typically present with a single lesion confined to the tattooed area. Histopathologically, tuberculoid (rather than foreign body) granulomas are more commonly seen [13].

Sarcoidal

There are several reports describing the occurrence of sarcoidal granulomas in tattoos of different colors, with and without systemic manifestations of sarcoidosis [14-21]. Skin biopsies show dermal to subcutaneous sarcoidal granulomas with admixed tattoo pigment [2]. The pathogenesis of this phenomenon is thought to be secondary to a local hypersensitivity reaction to a tattoo pigment or an isomorphic (Koebner) response. However there are no reliable histologic indications to definitively distinguish a sarcoidal tattoo reaction secondary to hypersensivity from a Koebnerization phenomenon of a tattoo due to underlying systemic sarcoidosis [1]. Careful consideration of the patient's clinical signs and symptoms is warranted to determine if further workup for systemic illness is appropriate (Figure 2).

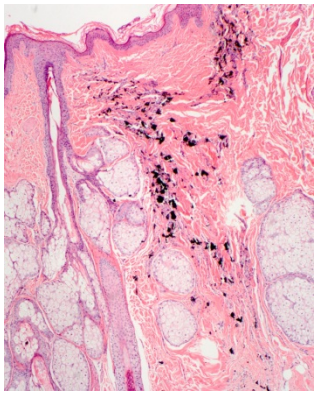

Figure 1: Traumatic tattoo secondary to lead pencil. Pigment deposition is evident throughout all levels of the dermis.

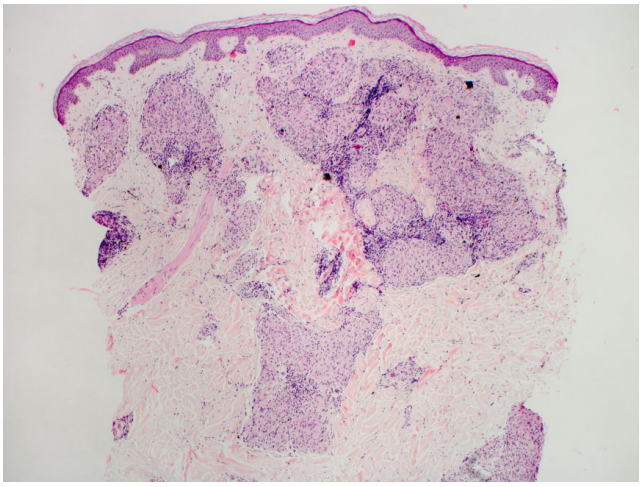

Figure 2: Granulomatous reaction to red ink. Low power examination of a punch biopsy demonstrates sarcoidal granulomas amongst scattered pigment.

Interface reaction patterns

Lichenoid

A lichenoid reaction pattern is believed to be the most common inflammatory response encountered in tattoo reactions, and is thought to arise from a combination of a delayed hypersensitivity response and an isomorphic reaction to the trauma of tattooing [22-25]. Once again, they are most commonly reported in tattoos containing red dye of various compositions [22-25]. Lichenoid tattoo reactions can be clinically and histologically indistinguishable from idiopathic lichen planus. Biopsies of lichenoid tattoo reactions show irregular acanthosis and vacuolar alteration of basilar keratinocytes with tattoo pigment intermixed in a band-like infiltrate of lymphocytes that obscures the dermoepidermal junction.

Cutaneous lupus erythematosus like reactions

The term "cutaneous lupus erythematosus–like tattoo reaction" is used to describe vacuolar interface dermatitis, and perivascular and periadnexal inflammation in a patient without signs or symptoms of systemic lupus erythematosus. An isomorphic response to the trauma of tattooing and delayed hypersensitivity to tattoo ink components are the presumed mechanisms behind both lichenoid and vacuolar-type interface tattoo reactions [26,27].

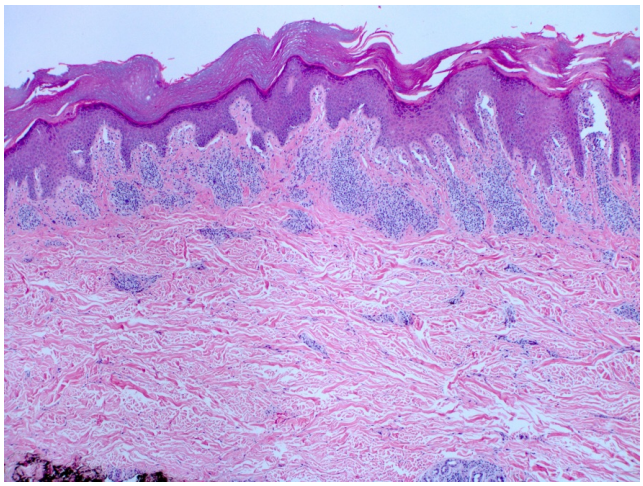

Figure 3: Lichenoid reaction to red ink. The epidermis demonstrates a lack of parakeratosis, wedge-shaped hyergranulosis, and regular acanthosis with prominent saw-toothed rete ridges. Dense inflammation is present at the dermal epidermal junction. Pigment is demonstrated in the mid to lower dermis.

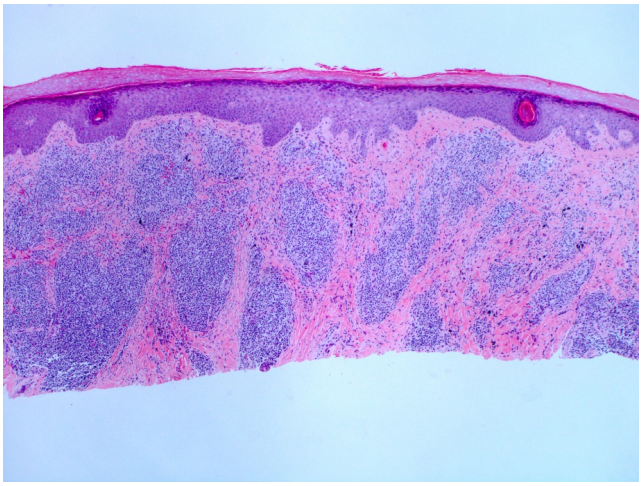

Figure 4: Granulomatous reaction to red ink. A shave biopsy demonstrates discrete granulomas present in both the papillary and reticular dermis. There is sparse admixed pigment.

Pseudolymphomatous reactions

Tattoos may also lead to delayed reactions against the pigment [3]. They may occur within weeks or as late as 15 years after tattoo placement [3]. Of interest is the development of a delayed pseudolymphomatous reaction, which is thought to occur as a result of chronic antigen stimulation from the exogenous ink substance, leading to an abundance of lymphocytes [6]. The clinical appearance is characterized by red to violet indurated plaques or nodules [6]. Histopathologic features that help to distinguish pseudolymphoma from malignancy include the presence of germinal centers, a mixed cell infiltrate, prominent vasculature, and preferential involvement of the upper dermis as opposed to the lower dermis. Immunohistochemistry can further confirm this diagnosis, as it will reveal a polyclonal lymphocytic population. This differentiation is important as tattoo sites have also been the location of cutaneous malignancies (further described below) (Figure 3).

Localization of Disease

Tattoos and neoplasms

Tattoos have been reported in association with various cutaneous malignancies, including basal cell carcinoma, squamous cell carcinoma, melanoma and leiomyosarcoma [28]. The development of neoplasms in tattoos may be due to local skin trauma. In addition, the composition of tattoo inks has been shown to contain potentially hazardous compounds that could be carcinogenic [28,29]. For example, blank inks contain hazardous carbon byproducts of soot in amounts far above the acceptable level for drinking water [29]. Nevertheless, a wide variety of cutaneous malignancies may develop within tattoos, including melanoma [30-32]. A thorough skin examination is advisable to avoid delayed clinical recognition of melanomas arising in tattoos. The histopathologic identification of melanomas in tattooed skin may be challenging, since macrophages laden with tattoo pigment can appear similar to areas of regression in melanoma [31-33]. In such instances, immunohistochemistry is

essential in obtaining an accurate diagnosis. In patients with confirmed melanoma who are undergoing sentinel node biopsy, documentation of a tattoo (if present) is important since tattoo pigment may be deposited in lymph nodes and clinically mimic metastatic melanoma [34]. Finally, the histopathologic differential of nonmelanoma skin cancer in association with decorative tattoos should include pseudocarcinomatous hyperplastic inflammatory reactions, as these reactions can mimic squamous cell carcinoma and keratoacanthoma [28].

Tattoos and infections

Infections with bacterial, viral and fungal species can occur after tattooing, sometimes with considerable delay [4]. They can occur anywhere from a few weeks (as in the case of acute pyogenic infections) to decades, as in inoculation leprosy [4,11]. Acute bacterial infections are clinically recognizable and are rarely biopsied. While there are no data regarding incidence, pyogenic infections caused by Staphylococcus aureus or Streptococcus pyogenes (such as impetigo, folliculitis, furunculosis, abscesses, or cellulitis) likely occur with relative frequency [3]. The presence of a tattoo should not alter the treatment approach in these situations (Figure 4).

Conclusion

With the rising popularity and social acceptance of decorative tattoos, dermatologists are more likely to encounter tattoo-related complications. As newer tattoo inks are developed and utilized, it is expected that the rate of reactions will rise. A deeper understanding of the most common histopathologic reaction patterns ideally will result in increased clinical detection of situations requiring additional evaluation, whether it is for an underlying infection, systemic involvement of disease, or to rule out a potentially deadly malignancy.

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