Novel Alginate-Derived Hydrogel Wound Dressing for the Treatment of Fresh Tattoos and Review of Tattoo Wound Care Management Practices

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Abstract: Tattooing and body modification has grown in popularity with more than 10 million procedures being performed in the United States annually by 2014. The management of the wounded skin of a freshly completed tattoo is often not managed with medical-grade wound care products with many tattoo studios in the United States using non-sterile food grade plastic wrap or absorbent meat packaging wrappers to cover fresh tattoos. Regulation of the tattoo industry in the United States is highly fragmented with many states lacking regulation regarding appropriate care for a fresh tattoo. Problems with the healing tattoo include bleeding, exudation, crusting, scab formation, infection, scarring, and loss of tattoo ink. I will review the current trends in tattoo wound management including a new sterile hydrogel wound management system.

Keywords: tattoos, tattooing, wound care, sterility, hydrogel

INTRODUCTION

Decorative tattooing can trace its origins into the prehistoric times.[1] Popularity in the United States has grown steadily but has recently experienced a boom in growth with market research estimating a 10% annual increase in the number of new tattoos applied. The current prevalence of tattoos in the United States is currently estimated at more than 45 million individuals with at least one tattoo. The tattoo industry is not currently regulated by the Food and Drug Administration. State and local health departments have taken interest in the tattoo industry, but regulations vary with attention paid mostly to the prevention of cross contamination from one client to the next while ignoring the the lack of packaging validation of most tattoo needles or tattoo ink sterility and ingredients. Similarly, most health departments do not specify the types of products that can be used to cover a completed tattoo, leaving tattoo artists free to use a variety of products not intended for the purpose of wound care.

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The application of a professional tattoo is achieved by a range of tattoo needles which are actually clusters of needles ranging from 0.20 to 0.35 mm in diameter. Although individual needles may be rarely used, it is more common to use clusters from 5 to 15 needles in various configurations that allows the artist to work ink into the skin. The needles are solid bore, and ink adheres to the needles via capillary action between the needles and by textural irregularities on the surface of each individual needle.

Tattoo needles puncture this skin to depths of 500 to 2000 microns [1] creating a wound and depositing tattoo pigment particles in the dermis. The wounded skin follows typical wound healing mechanisms including hemostasis, inflammation, proliferation, and maturation phases. The relevance to the tattoo is that during the initial phase of hemostasis, tattoo ink particles are swept upwards by both blood and plasma, resulting in ink loss. Additional ink loss is likely to occur during the inflammatory phase in which neutrophils migrate into the wound and trigger removal of some of the tattoo pigment particles. This leads to appearance of tattoo pigment within region lymph nodes for many years following the tattooing procedure.[2] Additionally, blood or plasma that forms a crust or scab on the surface of the skin is often inadvertently rubbed away from the fresh tattoo resulting in epidermal injury and focal cosmetically significant loss of tattoo ink which some tattoo artists describe as “holidays” within the tattoo. These focal

defects in the tattoo require repeat tattooing of the affected areas after healing with the cost in time and money often borne by the tattoo artist.

Currently, tattoo artists in the United States cover a completed tattoo with petroleum-based products such as Vaseline or Aquaphor and then wrap the tattoo with non-sterile, food-grade plastic wrap such as Saran Wrap and secure in place with tape (Photograph 1). Since plastic wrap has no absorptive or hemostatic properties, accumulation of blood, plasma, and tattoo ink can seep out from under the dressing. To combat seepage of potentially infectious wound drainage from this covering, the tattoo artist often places a non-sterile kitchen grade paper towel at the bottom of the dressing, referred to as a "blood catcher" by some tattoo artists.

Another treatment of a freshly completed tattoo includes the use of food-grade absorbent meat packaging sponges such as Dry Lock tiled together and held to the skin with tape. Unlike plastic wrap, these absorbent pads are comprised of layers of fibers and sometimes absorbent polymers that draw liquid away from the surface of the skin and into the dressing. These products are not sterile and tend to have a drying effect on the surface of the wound, which can result in residua from the fresh tattoo accumulating at the surface creating an exudative crust. Petroleum-based products are also often used as an adjunct to this type of dressing.

Additional treatment of freshly completed tattoos includes the use of medical-grade polyethylene film with a pressure sensitive polyurethane adhesive. The archetypical product of this type is 3M Tegaderm. This product no longer enjoys patent protection and so various cloned versions have appeared on the market under various product names. While these materials can offer a barrier dressing to a fresh tattoo, they lack any absorptive capabilities and a heavily exudative tattoo may produce accumulations of fluid between the dressing and tattoo. Removal may be problematic in some cases, contributing to epidermal injury.

Remaining options for tattoo dressings can include more traditional wound care products such as medical-grade gauze sponges and wraps, however, the desire of tattoo artists to directly visualize the freshly completed tattoo through the dressing as well as cost issues have reduced adoption of traditional wound care products in the tattoo industry.

HYDROGEL-BASED WOUND CARE PRODUCTS

Hydrogels are three dimensional networks of natural or synthetic polymers dispersed in water. They are highly absorbent of water, and are able to hold up to 99.9% of their weight in water, owing to intercalation of hydrophilic functional groups comprising the polymer side chains. Hydrogels are widely used in health care for medical-grade wound care dressings because of their ability to provide a moist wound healing environment, their ability to absorb blood, serum, plasma, or wound exudate, and their bacteriostatic or bactericidal properties. Some hydrogels, such as calcium alginate-based hydrogels, have inherent hemostatic properties and are capable of significantly reducing bleeding from wounds.[3] Hydrogels can exist as entangled networks of polymers by electrostatic interaction or as a more rigid gel by covalent bonds. Electrostatically-entangled hydrogels can be spread over an area such as an abrasion or burn but then require a secondary dressing to cover the gel and to hold it in place. Covalently cross-linked hydrogels are usually not spreadable but can be cut to fit to specific shapes and individually packaged. Seaweed masks applied in salons are examples of this type of hydrogel product, though many examples of cross-linked hydrogels are used in medical practice settings as well. Covalently bonded hydrogels can also be cross-linked to secondary gauze dressings for medical applications.

A NOVEL HYDROGEL-BASED DRESSING FOR THE TATTOO INDUSTRY

We review a novel product designed for the tattoo industry, branded SkinLock Tattoo Hydrogel. The product is comprised of alginate polymers derived from seaweed and cellulose polymers modified to improve aqueous solubility. The product uses a novel approach of varying the solubility of alginate within the hydrogel network to allow for the conversion of a water soluble, spreadable hydrogel when alginate is present in its sodium salt but an insoluble firm gel when alginate is present in its calcium salt. Sodium Alginate is soluble in water, whereas calcium alginate precipitates from solution in a film-forming reaction. The

application of SkinLock is thus a two-step process: the first step is to apply the sodium alginate-containing hydrogel to the freshly completed tattoo; the second step is to then apply a light spray containing calcium to the hydrogel, causing substitution of monovalent sodium for the divalent calcium, resulting in the formation of a transparent, flexible, absorptive membrane. Thus, any quantity of hydrogel can be applied to a fresh tattoo of any size or configuration and then fixed in place by the spray. Since the product contains tackifiers (materials that improve adhesion), no secondary dressing or tapes are required (Photograph 2). Additional ingredients include anti-bacterial and anti-fungicidal agents to prevent or reduce the growth of microbes on application to the tattoo. Since the product is water-soluble, removal is simple and occurs with submersion in water, reducing sheer forces and secondary injury that can occur in the removal of other types of dressings such as polyethylene films secured by polyurethane adhesive films such as 3M Tegaderm, Tatuderm, or other products in this category.

Microbiocidal Activity of SkinLock Hydrogel

We tested SkinLock tattoo hydrogel's ability to prevent growth of a typical range of aerobic bacteria and fungus in vitro to insure ongoing package sterility and also as a surrogate for clinical exposure to microbes during application and use.

PHOTO 1. Typical management of a freshly completed tattoo using non-sterile food-grade plastic wrap. Photograph courtesy of Northeast Tattoo, Minneapolis, MN.

PHOTO 2. Fresh tattoo sealed with SkinLock Tattoo Hydrogel and Sealant Spray. No additional dressings are required. Photograph courtesy of Northeast Tattoo, Minneapolis, MN.

MATERIALS AND METHODS

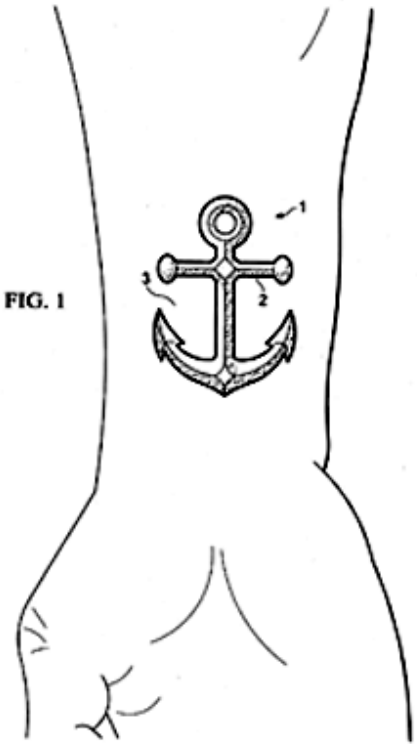
In vitro microbiocidal testing

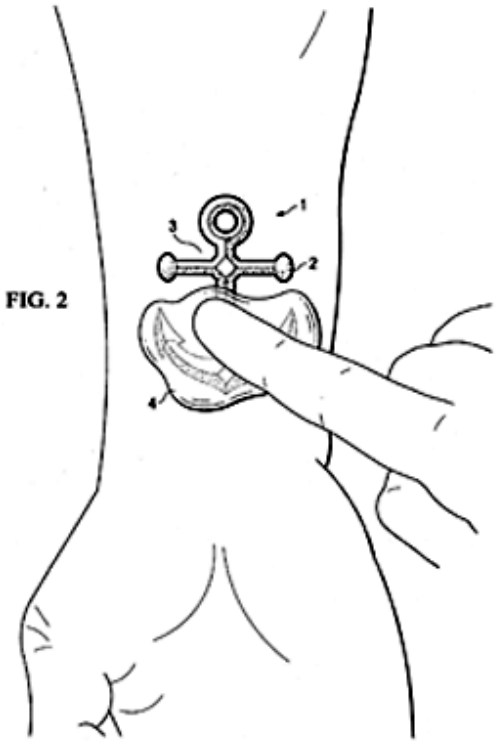
We performed in vitro testing of SkinLock tattoo hydrogel at Bell International Laboratories in Minneapolis, MN. In these tests, we inoculated individually packaged SkinLock tattoo hydrogel against aerobic gram-negative and gram-positive bacteria and also fungus (Table 1) and quantified colony forming units (cfu) of microorganisms using standard operating procedures (SOP #41-002 Revision 1). We performed the first test on commercially packaged SkinLock tattoo hydrogel (product batch number WCL-010713-7.0) on 01/13/2013 and then repeated the test with additional packages of SkinLock tattoo hydrogel from the same production batch to evaluate shelf stability of the microbiocidal activity of the product. Results are given in colony forming units per gram of product (cfu/gm).

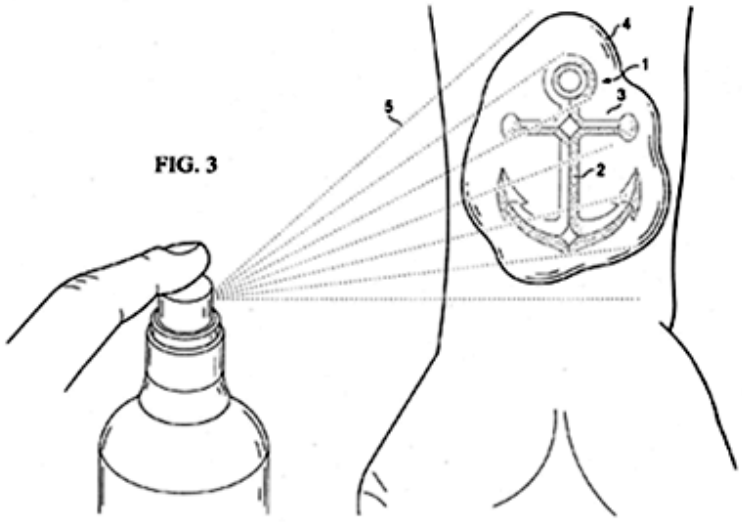
Field application of the product

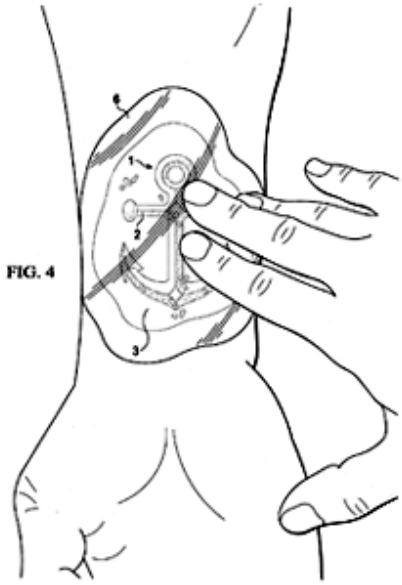
SkinLock application to the freshly completed tattoos was performed in the following steps according to the manufacturer's recommendations:

1. The freshly completed tattoos was gently cleaned removing any blood or surface matter, exposing the tattoo for treatment (Figure 1).
2. A thin coat of SkinLock tattoo hydrogel was applied to the fresh tattoo including a small framing of non-tattooed skin surrounding the fresh tattoo (Figure 2).
3. A very light mist of the SkinLock tattoo sealant spray was applied to the tattoo (Figure 3).
4. The tattoo was observed to be palpably sealed within seconds of application of the spray (Figure 4).









Application of SkinLock Tattoo Hydrogel and Sealant Spray

Figure 1. Freshly completed tattoo after removal of surface residua (blood, tattoo ink, products used during the tattooing process. **Figure 2**. Application of SkinLock Tattoo Hydrogel in a thin layer covering the fresh tattoo and ½ inch framing around the tattoo using a gloved finger. **Figure 3**. Application of SkinLock Tattoo Sealant Spray in a very fine mist 12-18 inches away from the tattoo. **Figure 4**. The tattoo is now sealed behind an antiseptic film layer and can be lightly palpated.

Reference Key: 1. Undamaged skin adjacent to the tattoo. 2. The client's skin containing the new tattoo. 3. The undamaged skin adjacent to the tattoo. 4. Hydrogel spread over the surface of the tattoo and surrounding skin. 5. SkinLock Sealant Spray misted onto the hydrogel surface. 6. The hydrogel has been converted into a film layer and is palpable and dry to the touch.

RESULTS

Microbiocidal Analysis of SkinLock Tattoo Hydrogel (Table 1)

	Mixture A	**Mixture B**	**Mixture C**
Control	2.1 x 10^7 cfu	2.5 x 10^7 cfu	2.1 x 10^7 cfu
7 days	<10 cfu	<10 cfu	<10 cfu
14 days	<10 cfu	<10 cfu	<10 cfu

First Inoculation 01/13/2013

	Mixture A	**Mixture B**	**Mixture C**
Control	1.9 x 10^7 cfu	2.1 x 10^7 cfu	1.9 x 10^7 cfu
7 Days	<10 cfu	<10 cfu	<10 cfu
14 Days	<10 cfu	<10 cfu	<10 cfu
28 Days	<10 cfu	<10 cfu	<10 cfu

Second Inoculation 05/02/2013

Mixture A: Escherichia coli (ATCC#8739), Pseudomonas aeruginosa (ATCC#9027)
Mixture B:Staphylococcus aureus (ATCC#6538), Pseudomonas aeruginosa (Bell), Burkholderia cepacia (Bell)
Mixture C: Aspergillus niger (ATCC#16404), Candida albicans (ATCC#10231)

Microbiocidal analysis of SkinLock Tattoo Hydrogel demonstrates biocidal activity eliminating >99.9999% of gram-positive, gram-negative aerobic bacteria and fungus.

SkinLock demonstrated sufficient tack to remain adherent to fresh tattoos, even when bleeding and wound exudation were present. SkinLock was fully optically transparent over all colors of tattoo ink allowing immediate visualization of the freshly completed tattoo.

DISCUSSION

Tattooing induces wounds into the dermis to depths of 2,000 microns. The healing tattoo undergoes typical wound healing processes but with the added component of cellular encapsulation of tattoo pigment particles in the dermis resulting in a permanent cosmetic tattoo. The healing of a fresh tattoo is complicated by the loss of tattoo ink during the hemostatic and inflammatory phases of wound healing via trans-epidermal migration of tattoo ink, inadvertent removal of exudative crusting adjacent to the tattoo causing epidermal and dermal injury, and lymphatic elimination of tattoo pigment. Reduction in epidermal loss of tattoo ink by improved hemostasis, the prevention of exudative crusting, reduction of bacterial growth particularly associated with non-sterile, food-grade dressings, ease of application, and transparency of the dressing are all desirable features in a tattoo dressing achieved with SkinLock.

This testing demonstrates broad-spectrum microbiocidal activity of SkinLock tattoo hydrogel against a range of aerobic bacteria and fungus. Food-grade products such as plastic wraps and absorptive meat packaging are widely used in the tattoo industry in spite of a lack of legal regulatory marketing approval for this purpose. Furthermore, plastic wraps and food-grade packaging materials lack any demonstrable wound healing properties and should be avoided.

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