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# Art, Biology, and Engineering – A Review and Comparison of Piercing and Tattooing Practices

## About the Author:

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## Abstract:

Body modifications include a variety of processes from the less extreme form of painted body art, to the slightly more invasive practices of piercing and tattooing, to the medical procedures of breast augmentations and facial reconstructions. Piercings and tattoos are perhaps of the most common and most noticeable types of body modifications; they can add style and individuality to a person's outward appearance. For such a trendy practice, it may be useful and interesting to know some of the technical details behind its processes. This article presents a brief overview of the historical and social backgrounds regarding the evolution of body modifications. In addition, this article discusses the art in the biology and biomedical engineering behind the tools and techniques currently being used in the realm of body modifications – piercing and tattooing.

## Introduction:

It is known that the body changes with age and experience. For example, battle wounds can turn into scars. Sociologists suggest that these permanent marks of the past can be seen by

others as symbols of experience, strength, and dominance – qualities that were essential for our ancestor's survival. As a result, decorated skin may have been seen as a coveted trait by the ancients [1]. Psychologists suggest that rituals of initiation, rites of passage, and sexuality are some innate desires that may bolster an individual's ability to withstand pain for a permanent, trophy-like modification [2]. In addition, it has been suggested that the pain associated with purposeful self-mutilation allows individuals to connect with spirits from another realm. The pain may have been seen as a means of communication and sacrifice, in exchange for favors from the gods such as rain or crops necessary for survival [1].

Despite the unresolvable, psychosocial origins associated with a desire for self-mutilation, body modifications are nothing new to the human species and have been practiced by ancient populations around the world for thousands of years. Scarification is the process of purposely scarring the skin and the likely precursor of tattooing. The oldest form of preserved, modified skin is a result of scarification, and it dates as far back as 200,000 years. And, the oldest evidence for tattooing originated from 30,000 BCE in the form of mummified human skin, sharp bone needles, charcoal pigments, and red ochre – a natural, non-toxic pigment found in soils [1]. The practice of skin piercing, however, did not appear in history until later on. The oldest piercing found dates back 5,000 years in the form of earrings on mummified remains [3]. Later, in 2100 BCE, ancient Egyptians began practicing wide-scale tattooing and piercing [1]. Jewelry used in piercings was used to depict the status of the individual; only wealthy individuals were able to afford certain metals or imported materials [4]. Tattoos, on the other hand, served different purposes. Slaves were often tattooed with the name of their owner for identification, while women often had tattoos of abstract, geometrical designs, which has been suggested to be linked with fertility [4].

Social Overview:

Of course, the practice of body modifications has come a long way. What was once a painful, spiritual, or labeling ritual has now trickled into the classification of "art." It is generally accepted that prior to the 20th century, tattoos were commonly associated with religious affiliations or social status, while piercings were associated with certain social or age groups. Beginning in the 20th century, tattooing became common among the working class, sailors, prisoners, and various other social groups. In the 1980s, much of the west saw a spread in the punk and gay movements, which protested against the conservative middle class and the norms of society, and thus an associated rise in piercings, tattoos, and eccentric fashion styles [5]. It seems as a result, fashion designers took inspiration from what was once considered shocking and provocative, and made it the norm [6]. Some authors argue that piercings and tattoos have become nothing more than fashion accessories to the current generation [5]. Nowadays, it may even be considered abnormal to meet a female without her ear lobes pierced.

Exact and reliable statistics regarding the demographics for piercings and tattoos in the general population currently do not exist, although many research groups have attempted to collect data on small subpopulations, normally through solicited internet or phone surveys. However, it is estimated that – for both males and females – about 24% of people between the ages of 18 and 50 have a tattoo, while 34% of people between the ages of 18 and 50 have a piercing [7]. And, it is true that, in general, these permanent body modifications have increased in popularity in recent years across all age groups [8].

The rising prevalence and current practices of piercing and tattooing has led to some great safety concerns. Unlike painted body art, they do involve the risk of blood-borne pathogens. And, unlike breast augmentations and facial reconstructions, they are not considered

medical procedures. It must be noted that there currently exist no governmental regulations for body modification practitioners, though many unofficial agencies, such as privately funded piercing and tattooing schools, boast “certification” and “aseptic techniques” [9]. Although the Food and Drug Administration (FDA) of the United States does regulate certain tattoo pigments that are known to have caused severe cases of allergic reactions or non-trivial side effects, most materials and techniques used remain unregulated because tattooing and piercing procedures remain classified as cosmetic procedures with minimal or undefined health risks [10]. Thus, the rapidly growing industry has remained very much self-regulated with regards to licensing, sanitation, equipment used, and competency of the industry professionals [11].

Although the safety and regulations regarding piercing and tattooing lie in a grey area, the accessibility of these procedures to the public, in terms of cost and availability, are becoming less and less limited due to an increase in consumer demand. And, although most reputable piercing and tattooing establishments require individuals to fill out a consent form, there are no set requirements for informed consent. Rather, many of these forms were created for the protection of the establishment from being sued in the event of injury; they are not aimed at client protection. Piercings are often inflicted with infections, bleeding, and tissue tearing, while tattoos are often connected with itching and bleeding [9]. While these complications may seem minor, they are difficult to ignore in an industry that has bypassed strict government regulation. However, these complications can arise from any of the three stages of the piercing or tattooing process: preparation, application, and aftercare. Surveys have shown that most complications result from inadequacies in techniques of application, as well as hygiene regimens of application and aftercare [12]. Thus, for a safe acquirement of a tattoo or piercing, it is critical for both the

practitioner and the individual receiving the modification to provide optimal care and attention both before and after application.

Preparation: Sterilization Techniques

A survey conducted on 1598 freshman from the University of Bari in Italy states that while the average age for a first tattoo was 17.5 years, only 60.3% of these individuals acknowledged that acquired immune deficiency syndrome (AIDS) can be transmitted through improper sterilization techniques [13]. These statistics may seem alarming, as they indicate a large portion of individuals undergoing body modifications are unaware of the associated health risks. The term "sterile" is not, in fact, a guarantee of 100% clean. Sterility is defined as the log of the reciprocal of the probability of a survivor on a single item [14]. In other words, unless the probability of a single unit of a biological agent surviving on an item to be sterilized is zero, then that item cannot be considered 100% sterile. Therefore, all sterilized items are not 100% sterile, since it is impossible to affirm a concrete 100% probability of all biological agents dying from sterilization. One can only maximize sterility by using proper sterilization technique.

Three categories of sterilization exist: heat, chemical, and radiation sterilization. Since piercing and tattooing procedures involve contact with human tissue, chemical and radiation sterilization are considered too toxic and dangerous to use. Heat sterilization can be performed using either direct heat, for example when sautéing food, or steam, for example when steaming foods. Since it is difficult to maintain a uniform temperature using the direct heat methods, steam sterilization is more commonly used. In addition, it is non-toxic and relatively inexpensive. Steam sterilization is normally carried out an in autoclave machine, which uses steam under pressure to sterilize an object. This process is properly carried out at 121 degrees Celsius with saturated humidity. The time of exposure under these conditions, however, differs for different

microorganisms and infectious agents. The standard for hospital equipment steam sterilization is 30 minutes [14]. It is undeniable that proper sterilization techniques will ensure minimal possibility of transmission of blood-borne pathogens, especially like the notorious and deadly human immunodeficiency virus (HIV) [15].

A commercial autoclave machine can cost between a couple hundred to a couple thousand dollars, depending on the make and size. Research and medical grade autoclaves can cost much more. Most piercing and tattooing establishments will own a small autoclave machine, such as the one seen in Figure 1, to sterilize their piercing and tattooing needles and jewelry. Normally, when an individual arrives at a piercing and/or tattooing establishment, a practitioner will first ask the customer for details regarding the procedure they want performed. An experienced practitioner will subsequently start to autoclave the equipment needed, while the customer signs consent forms and waits.

Figure 1. Autoclave
Small, commercial autoclave with top closure. Image Source: Wikimedia Commons

Preparation: Equipment Used

Although both piercing and tattooing are often offered at one establishment, the processes differ greatly, and thus the equipment used differ as well. A piercing is normally formed via a single puncture of the skin using a clean needle, whereas a tattoo is normally formed via multiple

punctures of the skin using an ink-covered needle or needles. Both piercing needles and tattoo needles tend to be stainless, surgical steel, so they are rust and magnetization resistant [16].

The professional piercer most often uses a beveled, hypodermic needle to carry out a piercing. A picture of a typical hypodermic needle versus a solid needle can be seen in Figure 2. The hypodermic needle was originally invented for attachment to a syringe for drug injection [17]. These needles are hollow and feature a bevel on the end to decrease incision size upon puncture [17]. In recent years, much biomedical research has been dedicated to developing needles to minimize pain. The effect of pain has been shown to be highly dependent on needle sharpness, lubrication, force of insertion, and mechanical workload [18]. Needle gauge, or the diameter of a needle, has been shown to be directly proportional to pain sensation; an increase in needle diameter increases the likelihood of pain felt by the individual undergoing the procedure [18]. Therefore, a larger piercing gauge can be directly correlated to a more intense pain sensation during the procedure. The reason for the hypodermic needle's use in the cosmetic piercing industry, however, is unknown; it has been suggested that the hypodermic needle poses less trauma upon insertion, though no scientific evidence has been published to bolster this theory. Their widespread use in cosmetic piercing may simply be a result of the their widespread use in medicine; the availability of disposable, pre-sterilized hypodermic needles far exceeds that of disposable, pre-sterilized solid needles, which are most commonly used in sewing.

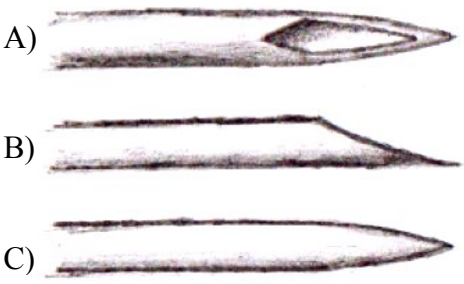


Figure 2. Needle Types
A) Top view of hypodermic needle point.
B) Side view of hypodermic needle point.
C) Solid needle point.

Tattoo needles, on the other hand, are always solid and are much smaller in diameter when compared to piercing needles. The smaller size is necessary for finer control of pigment deposition [16]. Tattoo needles normally consist of an array of needles in various shapes, depending on the specifications of the art piece being tattooed. For example, a circular needle array pattern may be used for shading, while a linear needle array pattern may be used for lining. Some variations in needle arrays can be seen in Figure 3. The blunt end of a tattoo needle array extends about 5 inches and is inserted and latched into a tattoo gun. A tattoo gun being held can be seen below in Figure 4. The tattoo gun itself is connected to a pedal, which turns the gun on when pressed and allows the tattoo artist to control the machine without having to use his or her hands. Together, the tattoo gun and pedal comprise the tattoo machine.

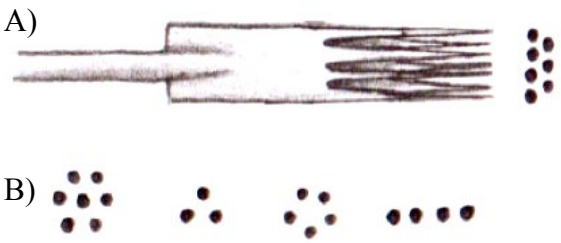


Figure 3. Tattoo Needles
A) Tattoo needle point and its associated ink pattern B) Tattoo needle array samples.

Figure 4. Tattoo Gun (Real)
Tattoo gun being held by a hand.
Image Source:
http://www.fotolia.com/id/21562810

A tattoo machine operates using electromagnetism. A simplified schematic of how a tattoo gun operates can be seen in Figure 5. When turned on, a voltage in the gun causes a metal bar, the armature bar, to move to an upward position and put pressure on a spring at the red asterisk in Figure 5. The upward posed armature bar causes a break in a circuit point, at the purple asterisk in Figure 5, causing a release of the voltage in the gun. Without that voltage, the spring pushes the armature bar back to a downward position, which again completes the circuit. The completed circuit then generates a voltage to push the armature bar back to the upward position, and the cycle repeats. This mechanically operated on-off circuit results in the armature bar vibrating somewhere between an adjustable 60 and 150 cycles per second. The bar is attached to the array of tattoo needles, and the vibrations cause the needles to move up and down. The distance the needles vibrate is called the "throw" of the tattoo gun. The throw can be adjusted by either screwing in or loosening a contact screw, which decreases or increases the flexibility of the spring, respectively. A less flexible spring allows only a slight up and down movement of the armature bar, and therefore a small throw, whereas a more flexible spring allow a larger throw [19]. Different throws are used for different thicknesses of skin being tattooed.

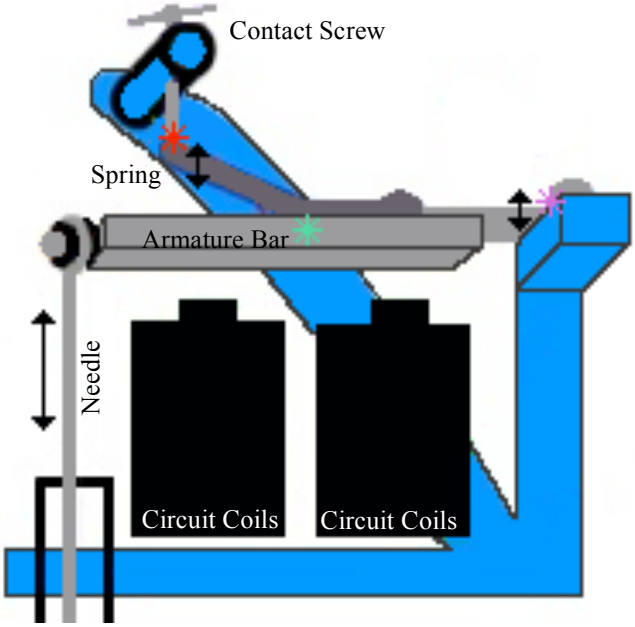


Figure 5. Tattoo Gun (Schematic)
The purple asterisk marks the point of circuit breakage, the red asterisk marks the point of rebound, and the green asterisk marks the pivot point of the armature bar. Black arrows indicate direction of movement.

Application: Knowledge on Human Anatomy

The skin is the largest organ of the body, by weight and by surface area; it acts as a barrier between the body and the environment [20]. To a tattoo and a piercing artist, the skin may be seen as a large piece of living canvas. However, by puncturing this organ, the rest of the body becomes exposed to the external environment, including all the infectious agents in the air and on the equipment used. The skin is composed of the epidermis, the dermis, and the hypodermis. A piercing is normally a trans-dermal procedure, meaning the piercing will puncture two opposing layers of skin with tissue in between. When jewelry is trans-dermally embedded in tissue, skin will tend to heal around it and form a fistula, or skin tunnel. Tattoo ink, on the other hand, is deposited within the skin, in the dermis layer. As a result, the epidermis will form over the tattoo and seal up the perforations originally induced by the tattoo needles for ink deposition. For a visual representation of the effect that piercing and tattooing has on the skin, see Figure 6.

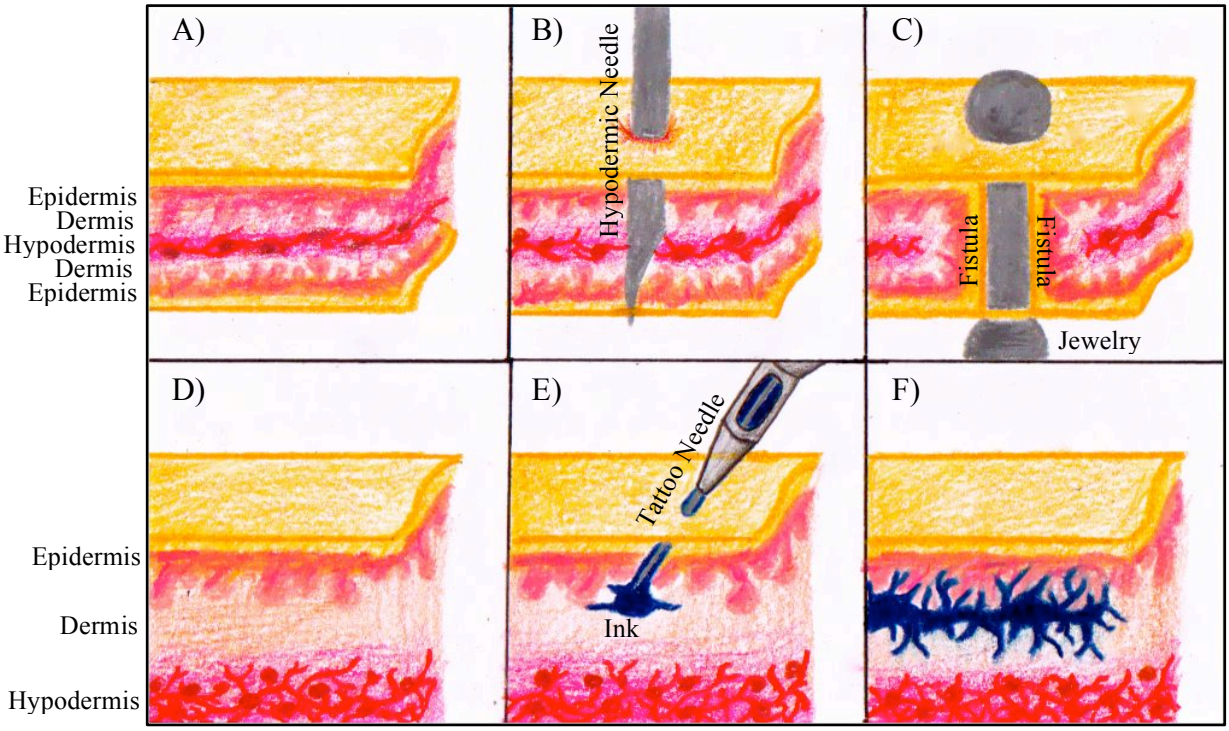


Figure 6. Modified Tissue
Depiction of (A) skin to be pierced, (B) skin being pierced, (C) healed piercing, (D) skin to be tattooed, (E) skin being tattooed, and (F) healed tattoo.

Aftercare:

Local infection is the number one reported complication resulting from tattooing and piercing procedures [9]. Despite aseptic preparation and application, body modifications can still contract various infections. These invasive procedures leave an open wound on the skin, which must heal just as any other injury. Inadequacies in hygiene regimens by the pierced or tattooed individual can often result in complications ranging from auricular perichondritis, or ear cartilage infection, to gangrene and necrosis, death of body tissue. An average wound can close up under the normal wound-healing process that most people are familiar with [21]. Under hygienic conditions, a tattoo can heal according to the normal wound-healing process, with some added scarring and skin peeling. A piercing, however, can remain susceptible to infection for months until the fistula forms, whose progress depends greatly on the location of the piercing and on the health of the pierced individual [2]. Although application may be the most memorable, aftercare may be the most tedious; a healthy recovery requires strict dedication in caring for the wound.

Closing Remarks:

Perhaps permanent, living art that comes at the cost of pain and danger seems luring to some individuals. However, regulating the equipment and techniques from which this art stems may prove difficult, since academic research and health risk priority in this industry is lacking. What can be tangibly regulated, however, may be informed consent. Individuals undergoing these modifications should be cognizant of the associated risks prior to consent. Nonetheless, implementation of any type of regulation will take time. Until then, knowledge of body modification equipment, techniques, and aftercare are the only self-controllable defenses against disease and disaster, for the sake of beauty. Although beauty may be pain, excessive pain should not result from ignorance.

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