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Forensic Micropigmentation

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Abstract

In the field of forensic science, the use of micropigmentation, cosmetic tattooing, micro blading or permanent makeup has had no relevance in criminal investigations and trials at this time. Moreover, there are no known recognized and established protocols for gathering and examining information concerning the forensic use of micropigmentation or permanent makeup in a criminal case. However, there has been an ever increasing incidence of civil cases and litigation in respect to micropigmentation. There is a definite need for objective analysis of these cases.

Classic tattooing has had a major impact on many criminal and civil cases for centuries. Micropigmentation is a form of tattooing, with its relevance and impact on society growing exponentially over the last 30 years. Therefore, it would be advisable to establish appropriate scientific protocols for future forensic micropigmentation and permanent makeup cases.

This research study includes the exploration of necessary parameters to establish such a protocol. Because of the historic roots of micropigmentation in tattoo techniques, current tattooing classification systems were discussed, highlighting their function and use in forensic investigations. Current civil cases in the field of micropigmentation were also discussed, emphasizing future implications where such a protocol is needed. This study concluded with the establishment of a procedural classification system for forensic use in micropigmentation evidence.

Keywords: Forensic science; Forensic micropigmentation; Cosmetic tattooing; Permanent makeup; Tattooing; Biometrics; Soft biometrics; Human identification

Abbreviations: SPCP: Society of Permanent Cosmetic Professionals; IAFIS: Integrated Automated Fingerprint Identification System; CBIR: Classification, Content Based Image Retrieval; NGI: Next Generation Identification; SMTs: Scars, Marks, and Tattoos.

Introduction, Brief History of Micropigmentation and Tattooing

Pictorial self-adornment has a long history. The earliest evidence of tattooing dates to the Ice Age, or more than 8000 BC [1]. These early body adornments were probably used to imitate the color of animals, have some mystical or religious purpose, or possibly camouflage; however, there is no clear evidence for these suppositions. Modern tattooing is in an extension of the primitive custom of painting the body. Examples of body paint include the red ochre found in prehistoric burial sites; blue woad, used by the ancient Britons; kohl, used in Asia to enhance the beauty of the eyes; henna, used on fingernails, in the Middle East; and, of course the war paints of the American Indian tribes [2]. The giant cosmetic industry today might well be considered a modification of primitive "war paint" customs. Early crude tattoo needles made of bone, and bowls that held pigment (usually soot) have been found in carves and rock strata in France, Portugal, Romania, and Scandinavia [1].

Egyptian mummies, as old as 4000 years, display tattoos

on women but not men. These tattoos were placed on dancing girls, concubines, and women singers, usually depicting the symbol of Bes, the goddess who protected women. However, men were tattooed in Libya. Male mummies with symbols of sun worship on their skins were found in the tomb of Seti I (1300 BC) [3]. In very early Greece, men were tattooed as a sign of nobility or proof of bravery. Later, as that custom declined, tattoos in Greece were limited to slaves and criminals. There is no evidence of tattooing among Hebrews even before the Mosaic Law, which forbade it [4]. There is a scarcity of tattoos on Jews, even nonreligious Jews, today [5].

Credit for the first documented use of the term "tattoo" belongs to Captain James Cook who was an explorer and Captain for the British Royal Navy [6]. His first voyage to the Tahitian islands took place from 1768-1771. It was during this exploration that Cook was first introduced to the practice of tattooing. The word tattoo is derived from the Tahitian/ Polynesian word "tatau," which means 'to mark' [6].

Modern tattooing can be dated mid-1880s, when Samuel O'Reilly exploited Edison's idea and designed the first electric tattoo machine in New York, later patented in Great Britain in 1891 by his cousin, Tom Reilly [7]. Tattoo machines used today by tattoo artists are very similar to the original O'Reilly unit, with some ingenious modifications and artistic embellishments. Many of these modern tattoo machines may be seen in the Tattoo Art Museum in San Francisco or at the World of Tattoos exhibit in Honolulu. All micropigmentation instruments now available on the market are derived in part from the original O'Reilly instrument. A standard tattoo instrument has the ability to change frequency from less than 30 cycles per second to an excess of 120 cycles per second [7]. Reciprocating and rotary tattooing machines represent the basic types. Of these two types, the double coil reciprocating machine is the conventional model most used by tattooing artists.

By the late 1970s, a greater number of women established themselves within the mainstream of tattoo art. Among these women, Mary Jane Haake, Winonna Martin, Shelia May, and Pati Pavlik were traditionally trained tattoo artists who began to offer intradermal makeup and reconstructive pigmentation. In 1979 there was a documented case of permanent eyeliner performed on Dr. Linda Dixon [8]. These women were unaware of each other's venture into intradermal cosmetics and reconstruction. However, they all shared a basic parallelism in development: expertise in classical tattooing, appreciation of cosmetology towards facial morphology, and insight in disciplines of makeup artistry.

In the 1940s, Moestin, Mauclaire, Duformentel, and Passot were generally given credit as the first group of doctors to introduce eyelash tattooing, a less-invasive alternative to eyelash grafting. In this procedure, the tattoo was delivered with a hypodermic needle and syringe, using a brown pigment. In 1984, Dr. Giora Angres published an article on the use of eyelash tattooing to create both eyeliner and eyelash enhancement for cosmetic purposes [9]. Dr. Angres was the first medical doctor to develop his own machine and pigments for the specific purpose of this eyeliner procedure.

During the summer of 1986, the first textbook, *Micropigmentation*, was written by Drs. Zwerling, Christensen, and Goldstein. This book provided a foundation of knowledge for the field, served as a reference guide, and created the basis for quality assurance and technical accuracy for this emerging field [10]. The book was published by Slack, Inc. in New Jersey. The most recent textbook on this subject, *Micropigmentation Millennium,* was written by Drs. Zwerling, Dixon, Christensen, and Goldstein in 2012 [8].

Currently there are numerous organizations devoted to safety, education, certification, and research in the field of micropigmentation in the USA: Allied Health Association, American Academy of Micropigmentation, Society of Permanent Cosmetic Professionals (SPCP), and The American Institute of Intradermal Cosmetics.

Definitions

Micropigmentation

Minute, metabolically inert pigment granules that are placed mechanically or manually below the epidermis for the purpose of cosmetic and/or corrective enhancement. Includes permanent makeup, cosmetic tattooing, and microblading [8].

Tattooing

Intradermal implantation of indelible pigments and/or scarification of the skin, placed mechanically or manually below the epidermis. Used to create legends, decorative art, and/or symbolism for the purpose of body adornment.

Biometrics: (SMT)

A. Biometrics are automated methods of recognizing a person based on an anatomical, physiological, or behavioral characteristic. Includes DNA, fingerprints, hand geometry, handwriting, iris, retina, vein, and voice characteristics. Biological features are traits that could be measured, including fingerprints, DNA, iris, and retina (Figure 1). Behavioral features would include features such as voice recognition or handwriting analysis.

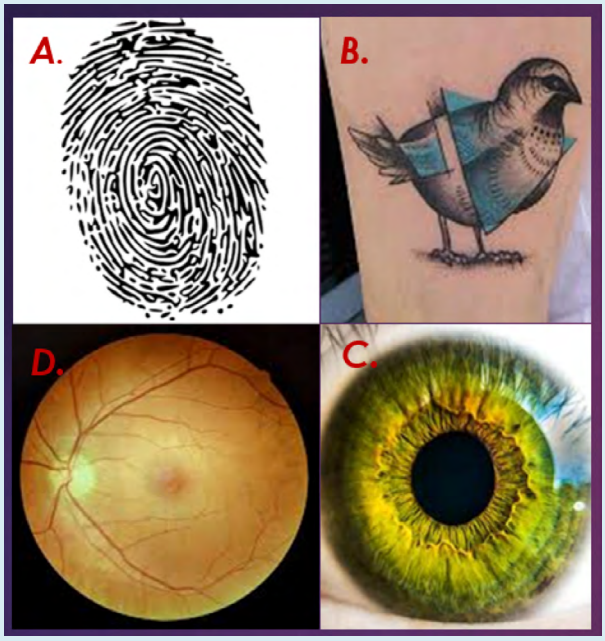


Figure 1: Biometric biological features. A. Fingerprint; B. Tattoo; C. Retina; D. Iris.

B. Skin markings like scars, birthmarks, and tattoos (SMT) are considered soft biometrics, easily measurable physical characteristics that can change (Figure 2).

Figure 2: Soft biometric examples. Easily measurable physical characteristics that can change: A. Scars, B. Markings, C. Tattoos.

Current Tattooing Classification Systems

Dermal Classification Systems Bertillon system of marks, scars, and moles: The science of anthropometry created in 1879 by Alphonse Bertillon, focused on the meticulous measurement and recording of different parts and components of the human body [11]. Generally, law enforcement of the late 19th and very early 20th centuries held that each individual possessed a unique combination of measurements relating to parts and components of the human body. In this system, comparing these measurements could be used to distinguish between individuals.

Automatic Biometric Identification Systems:

Automatic Biometric Identification Systems are based on computer stored data. One contributor to this data includes the FBI's Integrated Automated Fingerprint Identification System (IAFIS), the largest criminal biometric database in the world [12].

ANSI/NIST Classification (Tattoos) [13] (Figure 3):

The ANSI/NIST system is based on categories or class codes with labels as follows:

Human – Human Forms and Objects
Animal – Animal Forms and Features
Plants – Plants
Flags – Flags
Objects – Objects
Abstracts – Abstracts
Symbols - Insignias and Symbols
Other – Other Images

Figure 3: ANSI/NIST tattoo categories. These class categories are often broken down into subclasses. A. HUMAN; B. ANIMAL; C. PLANT; D. FLAG; E. OTHER; F. SYMBOL; G. ABSTRACT, H. OBJECT.

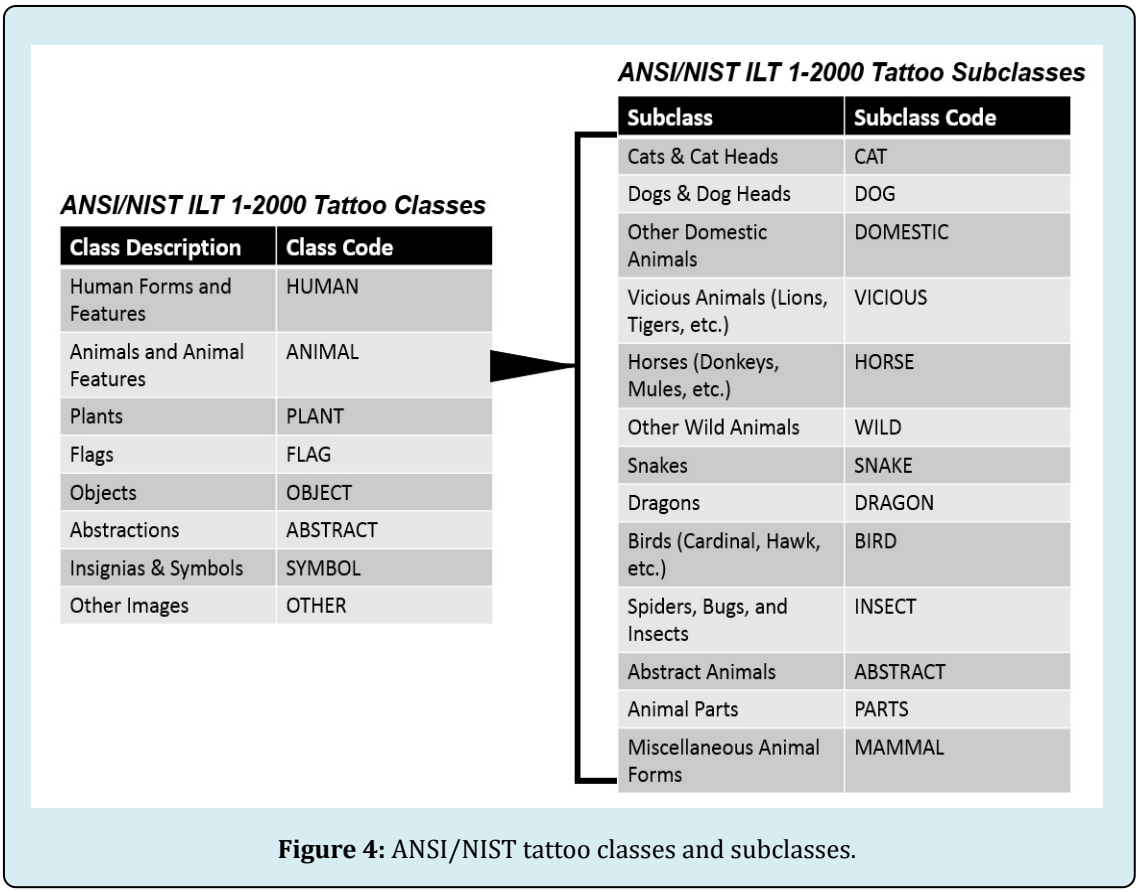
Each category has subcategories (Figure 4). For example, a tattoo is the intradermal implantation of indelible pigments and/or scarification of the skin to create legends, decorative art, and symbolism for the purpose of body adornment [13]. The process is achieved by various methods, including:

Tattoo To indicate a common tattoo or indelible image resulting from the pricking or injecting of the skin with a coloring matter.

Chemical An image created by the use of chemicals to burn the image into the skin.

Branded An image burned into the skin using a branding iron or other form of heat.

Cut The image was caused by incision of the skin.



ANSI/NIST ILT 1-2000 Tattoo Classes

Class Description	Class Code
Human Forms and Features	HUMAN
Animals and Animal Features	ANIMAL
Plants	PLANT
Flags	FLAG
Objects	OBJECT
Abstractions	ABSTRACT
Insignias & Symbols	SYMBOL
Other Images	OTHER

ANSI/NIST ILT 1-2000 Tattoo Subclasses

Subclass	Subclass Code
Cats & Cat Heads	CAT
Dogs & Dog Heads	DOG
Other Domestic Animals	DOMESTIC
Vicious Animals (Lions, Tigers, etc.)	VICIOUS
Horses (Donkeys, Mules, etc.)	HORSE
Other Wild Animals	WILD
Snakes	SNAKE
Dragons	DRAGON
Birds (Cardinal, Hawk, etc.)	BIRD
Spiders, Bugs, and Insects	INSECT
Abstract Animals	ABSTRACT
Animal Parts	PARTS
Miscellaneous Animal Forms	MAMMAL

Figure 4: ANSI/NIST tattoo classes and subclasses.

New Tattoo ID Classification, Content Based Image Retrieval (CBIR):

CBIR searches the database using the similarity of visual features: color, texture, and shape. Based on scale invariant feature transform (SIFT) features extracted from tattoo images and optional accompanying demographical information, our system computes feature-based similarity between the query tattoo image and tattoos in the criminal database [13].

Image Based Technology:

Next Generation Identification (NGI) will extend automated biometric identification capabilities beyond fingerprints and palm prints. Although law enforcement has used photographs of scars, marks, and tattoos (SMTs) for several years to help identify or eliminate suspects, the NGI will automate the process. In 2014, investigators will be able to query the NGI with descriptive data about tattoos to find images of potential SMT matches associated with individual's records.

Based on the Zwerling Procedural Classification System, micropigmentation can be categorized as either a cosmetic or corrective procedure (Figure 5). In the early development of micropigmentation, the procedure was known as blephropigmentation with the purpose of correcting alopecia of the eye lashes [14]. Soon thereafter patients were requesting eye lash enhancement and eyeliner procedures in order to avoid the need for makeup. Below is a summary of the various procedures that can be utilized by micropigmentation techniques.

A. Cosmetic: permanent makeup procedures that are performed to mimic conventional makeup

1. Eyes: eyeliner, eye lash enhancement, eye shadow
2. Eyebrow: liner, enhancement
3. Lips: liner, full lip
4. Breast: areolar enhancement
5. Face: blush, shadow

B. Corrective: paramedical procedures that are performed to correct disease and/or physical deformities

1. Simulation: hair loss cornea, nails, areolar reconstruction
2. Camouflage: vitiligo, port wine, skin pigmentation, scalp shading
3. Revision: scars trauma, burns, surgical
4. Resurfacing: wrinkles, microdermabrasion
5. Medical Markers: biopsy, cancer

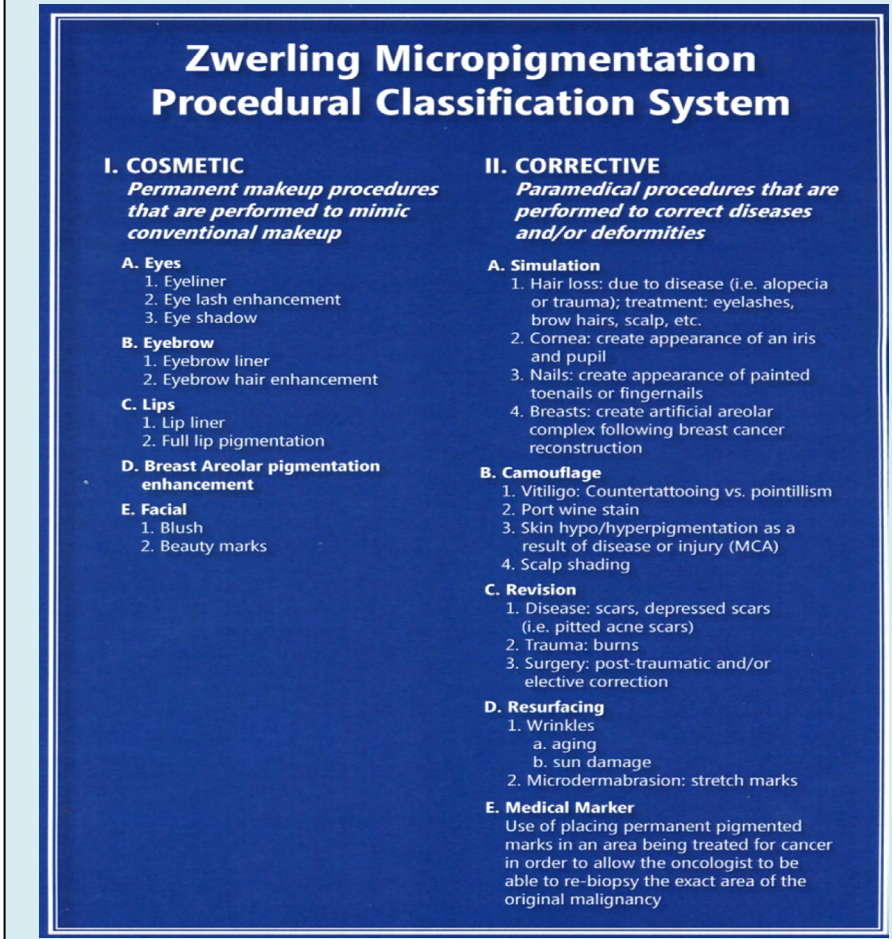


Figure 5: Zwerling micropigmentation procedural classification system.

Forensic Micropigmentation Protocols

Forensic Micropigmentation can be defined as the gathering and examining of physical evidence of permanent makeup or cosmetic tattooing in order to establish facts in criminal or civil court. Micropigmentation represents a type of Soft Biometric Trait which is an easily measurable physical trait that can change over a period of time.

The following protocols below represent a logical scientific approach for the forensic evaluation of micropigmentation in a victim:

Collect Evidence (Figure 6)

1. Exam Identify and record location of sample i.e. right lower eye lid.
2. Chain of evidence documentation.
3. Use of digital photography for documentation throughout entire forensic examination.

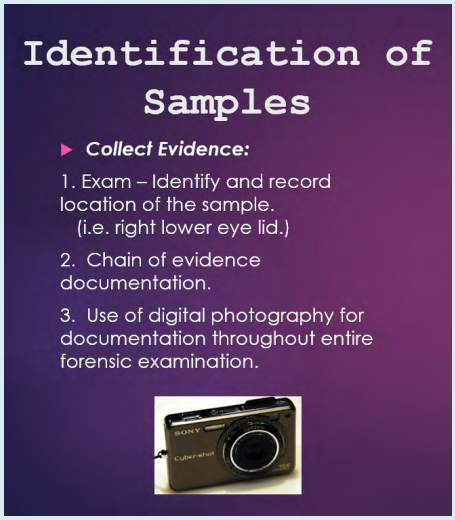


Figure 6: Identification steps of a micropigmentation sample.

Morphology use of Classification Systems (5-S, head shape, Oculo-facial Morphology, noses) (Figure 7)

1. Size: measure in metric with calipers/ rulers

2. Shape: irregular, random or consistent lines and/or patterns

3. Weight: in grams metric

4. Color (s): descriptive; use color key to assist in description; Fitzpatrick Scale 1-6.

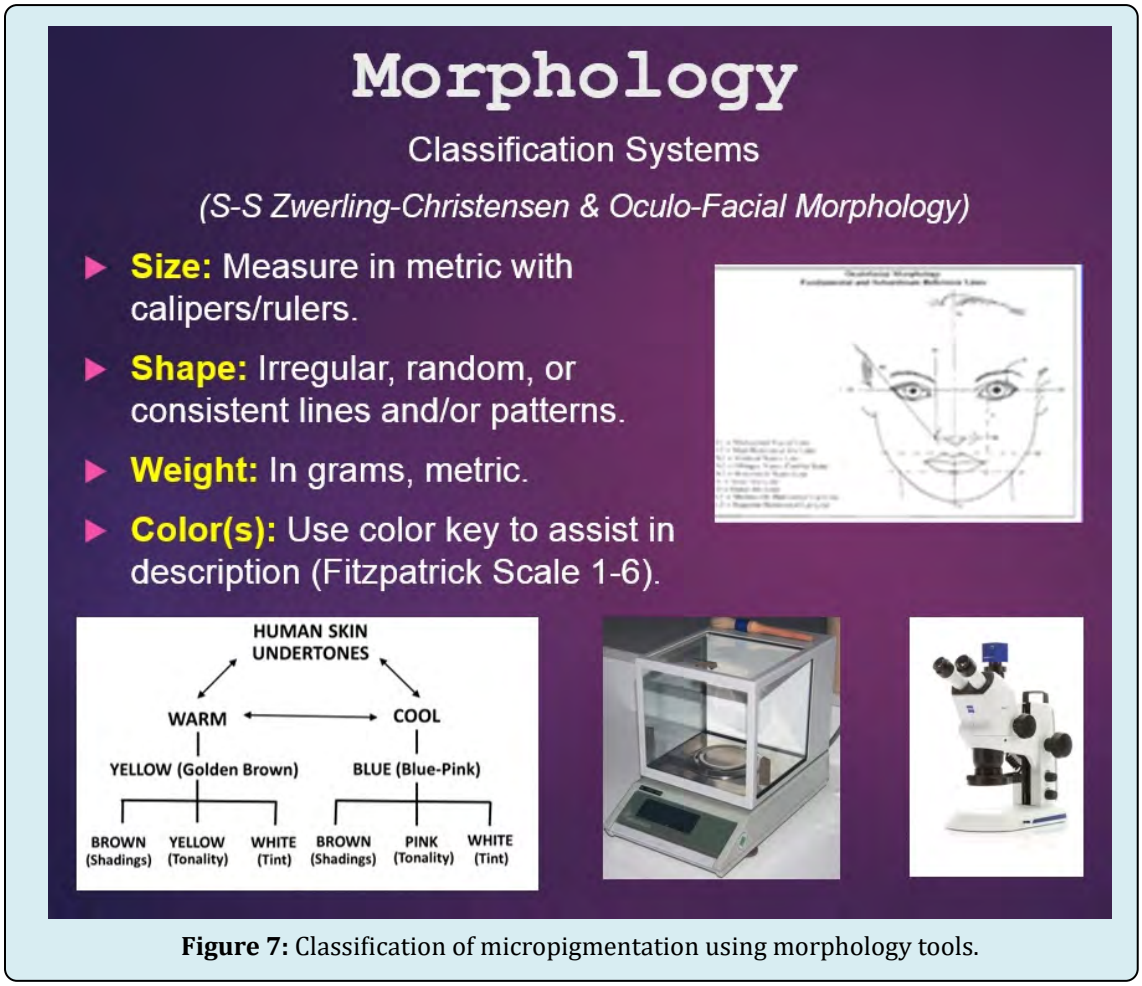


Figure 7: Classification of micropigmentation using morphology tools.

Physical Properties (Figure 8)

1. Macro evaluation represents the overall appearance of the micropigmentation procedure. By careful observation the forensic evaluator can identify various techniques used in creating the overall appearance of the micropigmentation procedure. These identifiers can be useful in determining the origin of previous treatments for that victim including type of machine used and specific artistic technique.

- **Distinctive artistic technique/style "CLIMB" artistic technique: Color, Line, Insertion, Movement, Borders**

i. "Korean Method"

ii. Pointillism

iii. Brush Stroke

iiii. Dimensional Use of Color:

Hue	Color
Value	Brightness
Tint	Addition of White
Shade	Addition of Black
Tone	Amount of Gray Added
Undertone	Cool or Warm Skin
Simultaneous Contrast	Effect of Surrounding Colors on Perception

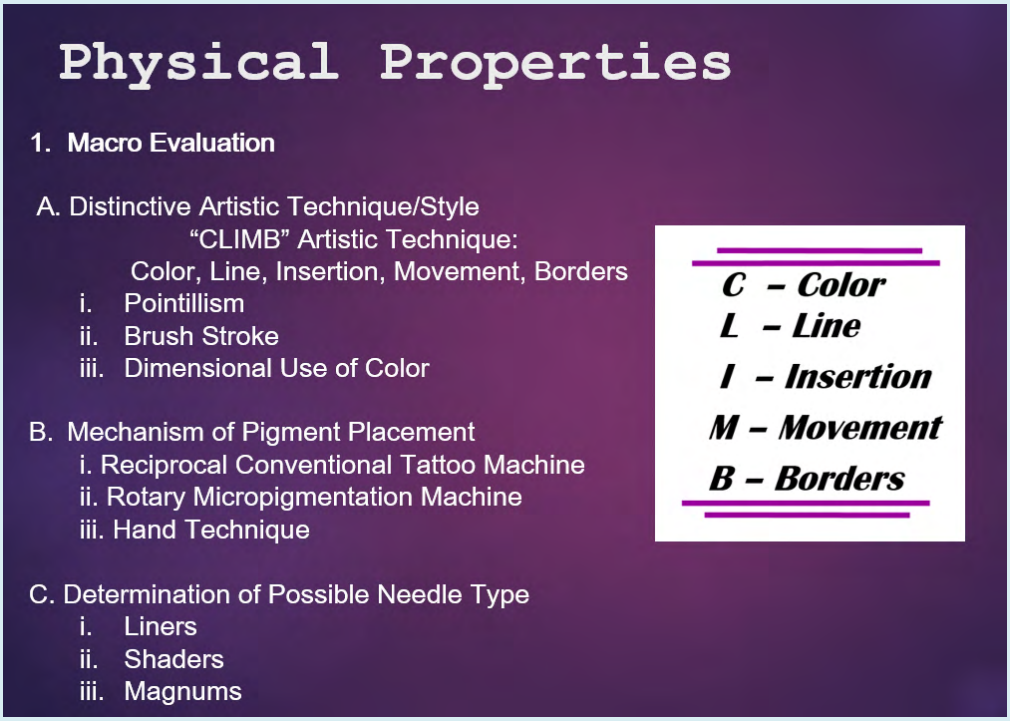


Figure 8: Macro evaluation protocol of micropigmentation physical properties using the CLIMB analysis.

- **Mechanism of pigment placement (Figures 9-12)**
  i. reciprocal conventional tattoo machine
  ii. rotary micropigmentation machine
  iii. Hand technique
  vi. Microblading

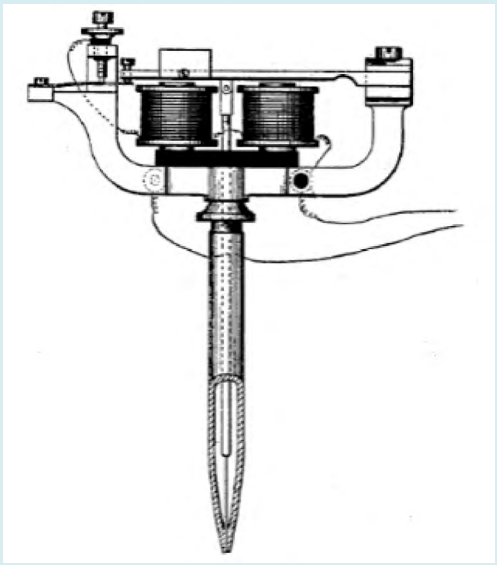


Figure 9: Original patent for rotary micropigmentation machine.

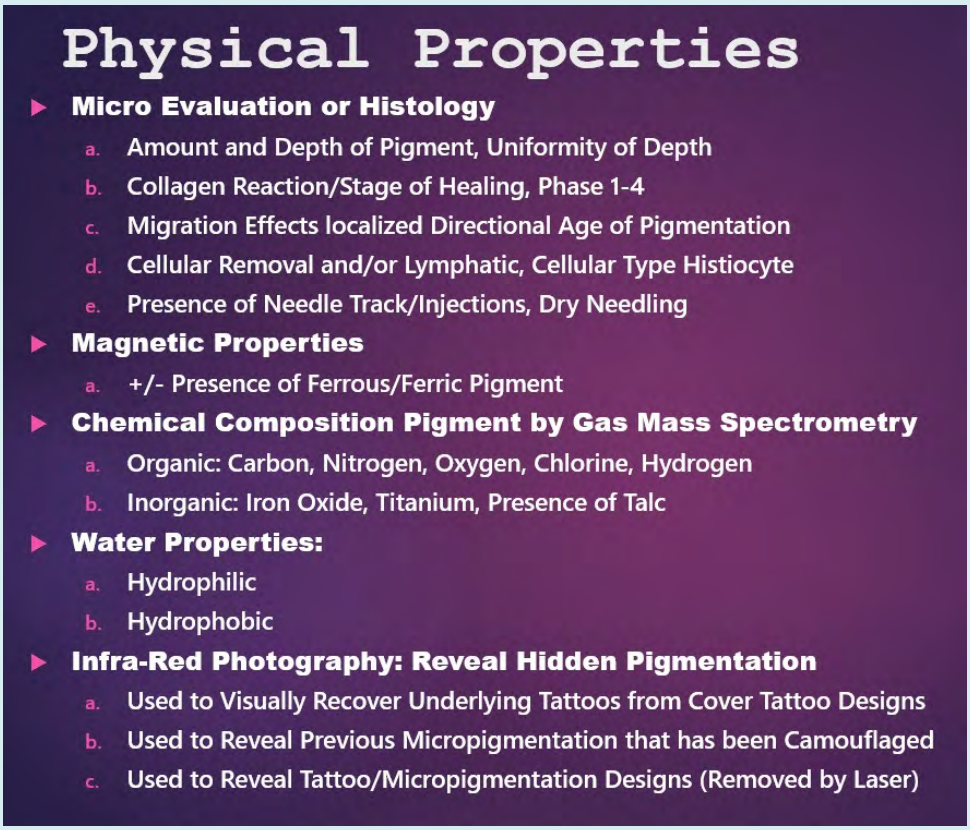


Figure 10: Micro evaluation protocol of micropigmentation physical properties.

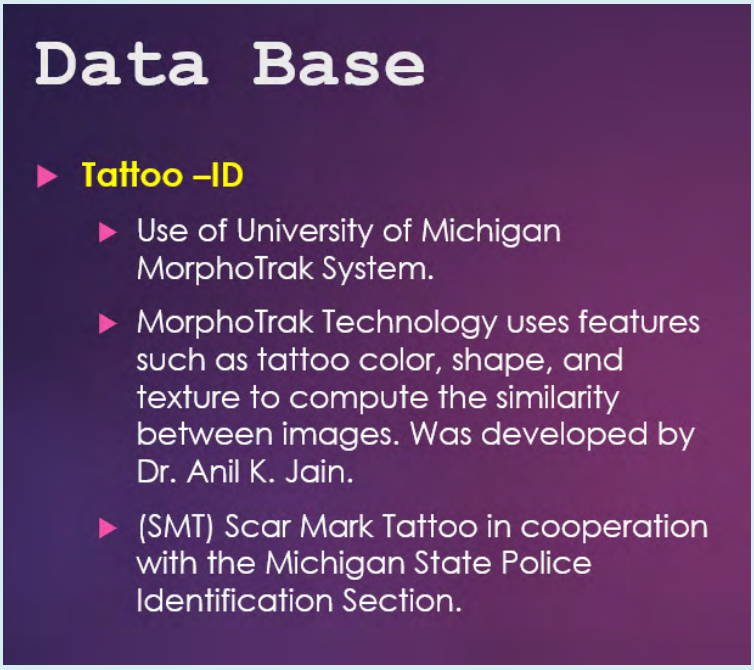


Figure 11: Tattoo identification tools through data base search.

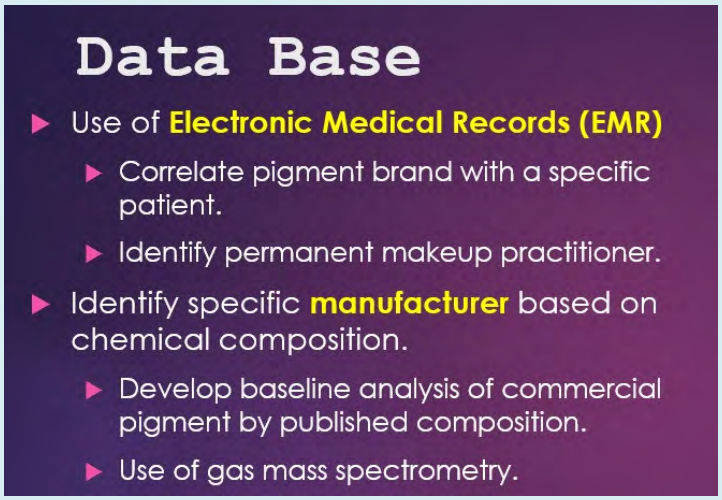


Figure 12: Data base tools and techniques.

➢ **Determination of possible needle type**

i. Liners
ii. Shaders
iii. Magnums

2. Micro evaluation or Histology
a. Amount and Depth of pigment and uniformity of depth; pigment located at which level of epidermis/dermis
b. Collagen reaction / Stage of Healing: Phase 1-4
c. Migration effects localized directional
d. Cellular removal and/or lymphatic removal; cellular type histiocyte, macrophage
e. Presence of needle tracks/injections; Dry Needling

3. Magnetic Properties +/- presence of ferrous/ferric pigments

4. Chemical composition of pigment by gas mass spectrometry Timko, et al. [15] found that, of 30 tattoo inks studied, the most commonly identified elements were aluminum, oxygen, titanium and carbon at 87, 73, and 67 percent respectively.
a. Organic: carbon nitrogen oxygen chlorine, hydrogen
b. Inorganic: iron oxide, titanium, presence of talc

5. Water properties
a. hydrophilic
b. hydrophobic

6. (IR) infrared photography
a. recover underlying tattoos from cover tattoo designs
b. reveal previous micropigmentation that has been camouflaged
c. reveal tattoo / micropigmentation designs that have been removed by laser
d. Tattoo removal methods

Simulation Studies

A. Reproduce physical environment
B. Reproduce physical conditions

Data Base

1. Use of electronic medical records (EMR)
a. correlate pigment brand with specific patient
b. identify permanent makeup practitioner
2. Identify specific manufacturer based on chemical composition
a. Develop baseline analysis of commercial pigments by published composition
b. Use of gas mass spectrometry

Discussion

Dermalpigmentation, commonly known as tattooing, has been present for centuries in our cultures for the purpose of body adornment. Classical tattooing consists of intradermally implanting pigments and/or scarification of the skin to create legends, decorative art, and symbolism for the purpose of body adornment. Micropigmentation is a separate specialty developed from tattooing with the placement of colorants into the skin for the purpose of cosmetic enhancement, medical correction, and/or aesthetic restoration.

Therefore, micropigmentation is differentiated from classical tattooing by its purpose, specialized training, and unique standards required to perform this procedure. Moreover, the use of other terminology such as “semi-permanent makeup” and “cosmetic tattooing” often leads to confusion and misrepresentation. The intradermal implantation of any pigment and/or needle causes permanent histologic alteration of the dermis even if the pigment fades;

moreover, the use of a term like "cosmetic tattoo" is an oxymoron and contradiction of terms. In 1986, Dr. Zwerling and Dr. Christensen created the word "micropigmentation" to better define this new technology as a distinct entity, a discipline separate from classical or traditional tattooing [8].

Edmond Locard, a renowned pioneer in forensic science and criminology stated decades ago his famous Locard's Exchange Principle. This theory relates to the transfer of trace evidence between objects in which "every contact leaves a trace". His theory states that when two objects come into contact with each other, one will take something from the other object or leave something behind. Micropigmentation is a soft biometric that follows the Locard Exchange Principle. The practitioner who applies micropigmentation to an individual imparts a unique artistic technique with specific pigments and needles.

In the macroscopic evaluation of a victim's permanent makeup, the investigator can gain valuable insight into the artistic technique used for the procedure. The CLIMB Technique describes the artistic technique used in the case. Careful analysis can determine that Machine v. Hand Method was used with single or multiple needle clusters. Moreover, microblading techniques or other unique applications methods might have been employed. Just as every contact leaves a trace, every practitioner has a unique method of performing micropigmentation that leaves his or her original marks on the client.

The FDA considers the pigments used in intradermal tattoos, including permanent makeup to be cosmetics and color additives. Therefore, they are subject to premarket approval under the Federal Food, Drug, and Cosmetic Act. However, the FDA has not exercised regulatory authority for color additives of permanent makeup pigments. This lack is derived from other competing public health agencies and a previous lack of safety problems specifically associated with these pigments. The actual practice of tattooing is regulated by local jurisdictions.

An exhaustive research of the internet reveals that there has been no circumstance to date where micropigmentation has been used as forensic evidence in a criminal case. However, there have been numerous civil litigations where appropriate forensic analysis could have impacted the civil case [16]. Most of the civil cases have been a disagreement in the cosmetic outcome. Moreover there have been legal issues concerning intellectual property and trademark rights. However, there have been certain legal actions involving medical complications from infections, delayed allergic reactions, and systemic inflammations in which a scientific protocol for forensic micropigmentation could have affected the outcome of the case.

In the early 1980s, there were a number of reports of foreign body reports that were a result of a reaction to talc powder that was mixed with the iron oxide pigments. Moreover, there have been a number of delayed hypersensitivity reactions to various metallic and organic pigments in the medical literature associated with classical tattooing. To date, the FDA has been made aware of more than 150 adverse events and is investigating additional reports sent to the manufacturer. Reactions that have been reported include swelling, cracking, peeling, blistering, and scarring as well as formation of granulomas (chronically inflamed tissue mass associated with an infection) in the areas of the eyes and lips. This type of delayed hypersensitivity reaction is consistent with Type IV delayed hypersensitivity. The inks associated with this outbreak were voluntarily recalled by the company that marketed them in 2004 [17].

In the spring of 2012, the FDA received reports of infections from contaminated inks, resulting in their recall and market withdrawal. In the fall of 2017, a firm voluntarily recalled several colors and sizes of tattoo inks, due to microbial contamination identified by an FDA survey [17]. In addition, concerns raised by the scientific community regarding the pigments used in tattoo inks have prompted FDA to investigate their safe use. FDA continues to evaluate the extent and severity of adverse events associated with tattooing and is conducting research on tattoo inks.

Careful chemical analysis of the pigment from a victim's permanent make-up could reveal unique, detailed properties of a specific manufacturer [18]. It would be possible to match that pigment to a specific practitioner who could possibly identify an unknown victim or even perpetrator.

Conclusion

With the estimated millions of cases of micropigmentation throughout the world, it is just a matter of time when micropigmentation could be an important forensic tool in identification of a victim or perpetrator in a criminal case. The purpose of this article is to introduce the use of micropigmentation as potential forensic tool in future criminal cases by providing a scientific forensic protocol for future development of micropigmentation as a scientific tool for criminological study and forensic analysis. By understanding micropigmentation techniques, pigments, and application methods, the forensic investigator will able to assist in victim identification as well as establish possible location and potential time lines of the crime.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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Notes

The following images are attributed to the sources listed below.

Figure 1:

A. "Free Photo Crime Finger Criminal Detective Touch Fingerprint - Max Pixel." Free photo Crime Finger Criminal Detective Touch Fingerprint - Max Pixel. Accessed July 9, 2019. https://www.maxpixel.net/Finger-Crime-Touch-Criminal-Fingerprint-Detective-150159.

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Figure 2:

A. "Free Image on Pixabay - Hand, Injury, Skin Abrasion, Gall." Hand Injury Skin Abrasion - Free photo on Pixabay. Accessed August 9, 2019. https://pixabay.com/photos/hand-injury-skin-abrasion-gall-474279/.

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Figure 3:

A. Thailand, Pitbull Tattoo. "Black & Grey Tattoo (Single Session)." Flickr. Yahoo!, October 6, 2017. https://www.flickr.com/photos/pitbulltattoothailand/37498140902/

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