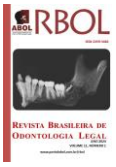
Revista Brasileira de Odontologia Legal – RBOL

ISSN 2359-3466 http://www.portalabol.com.br/rbol



Human identification

ON THE FORENSIC VALUE OF TATTOOS FOR HUMAN IDENTIFICATION – A LITERATURE REVIEW

Da importância forense das tatuagens para identificação humana – uma revisão da literatura

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Information about the manuscript:

Received: December 31, 2023
Accepted: January 20, 2024

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ABSTRACT

Disaster victim identification is structured according to international recommendations on the attempt to optimize forensic logistics. The International Criminal Police Organization (INTERPOL) establishes primary and secondary methods for human identification. This study aimed to revisit the existing literature to address the forensic importance of tattoos. The scientific literature has shown advances in the forensic analyses of tattoos specially when it comes to the application of especial imaging techniques, namely photography with infrared light to visualize latent tattoo inks and cover-up tattoos, as well as the use of biochemical processing to distinguish components of the tattoo inks. Other relevant aspect is the fields dedicated to tattoo descriptions in software used worldwide for disaster victim identification, namely PlassData. Coding systems have been proposed as well to facilitate communication in the human identification process. The future of forensic analyses of tattoos is promising considering the increase of research in recent years. Forensic practice might benefit from it with more scientific evidence to support the utilization of tattoo analyses in casework.

KEYWORDS

Forensic dentistry; Forensic medicine; Human identification; Tattoo.

INTRODUCTION

Recent data from major countries suggest an increasing popularity of tattoos worldwide[1]. Authors have noticed a prevalence of 18.5% of tattooed people in a sample of 11.709 individuals from Brazil, China, France, USA and Russia[1]. The most common profile of tattooed people are individuals between 25 and 34 years, having one tattoo and being females. Celebrating a milestone and self-embellishment were the predominant reasons to have a tattoo[1]. Another popular

reason to justify a tattoo was "individuality/distinction" (14.8%)[1].

Being distinctive enough to enable human identification is essential in forensic sciences. This is the premise of "uniqueness" a principle that together with persistence, immutability, classifiability and practicability should be inherent to methods for human identification[2]. The distinctive physical characteristics of a person can be original (from birth) or acquired (throughout life) [3]. The latter can be expressed in many forms – unintentionally (such as accidental scars and melanocytosis) or intentionally (via scarification, amputation and tattoos, for instance).

Some of the distinctive physical characteristics of a person can help *postmortem* (PM) recognitions. In short, these features may trigger recent or long-term memories of the observer that build up associations based on resemblance with a person met in life. PM recognitions, however, are not scientific, are prone to subjectiveness and can be influenced by post-traumatic stress (especially because the observer is usually someone close to the victim) [3]. Yet methods that aid recognition of the deceased should not be disregarded. Instead, scientific light must be casted on it to investigate the limits of its forensic value.

This study proposed a literature review on the forensic value of tattoos.

LITERATURE REVIEW

Primary means for human identification

The International Criminal Police Organization (INTERPOL) considers primary means for human identification the method that are based on solid scientific foundations. These methods are capable of human identification without depending on each other or any other additional means[4]. According to the most recent Disaster Victim Identification guide released by INTERPOL, ridgeology, odontology and genetics are the three traditional primary means for human identification. Alternatively, INTEPROL also has included the serial numbers that might be marked on surgical orthopedic or aesthetic appliances[4].

The primary means work on a comparative basis, between antemortem (AM) and PM data[5]. Taking odontology as an example, dental data registered in the patient's records could be relevant to support a comparison between dental features (that can be morphological, therapeutic, and pathological)[5]. These records normally provided by the dentist of the victim or by family members. Comparisons are made between the AM data that are usually radiographs and written files and the PM findings detected and registered during an autopsy[5]. In short, the comparisons should be between data of the same type, such as radiographs compared with radiographs. The compared dental records can lead to similarities (converging features), explainable discrepancies and unexplainable discrepancies[6]. Explainable discrepancies are often explained by the effects of time in the dental status, i.e. a tooth that was virgin and became decayed, or a restoration of two surfaces that became larger (or with a different restorative material, or even lost). Unexplainable discrepancies, on the other

hand, invalidate the identification process leading to an exclusion[5] – in other words, they show a situation in which is impossible to attribute an identity based on the available and divergent AM and PM data (e.g. a tooth that was restored AM and appeared virgin PM). After comparing AM and PM data, experts conclude following INTERPOL's standards as: positive identification, probable identification, possible identification, insufficient evidence, and exclusion[7].

- *Positive identifications means that there is an absolute certainty that AM and PM data belong to the same person.*
- *Probable identification means that specific characteristics converge between AM and PM data but both are minimal.*
- *Possible identification means that there is nothing that excludes the person, but AM and PM data are minimal.*
- *Insufficient evidence means that AM and PM comparisons cannot be made.*
- *Exclusion means that AM and PM data are from different persons.*

Secondary means for human identification

The term "secondary means" was created by INTERPOL to indicate methods that could have a presumptive outcome.[7] Examples secondary means are the personal belongings of the victim, descriptions of the victim's appearance, medical findings (such as prostheses), and tattoos. Authors[8] have found this term suboptimal, to say the least, because it gives the idea of existing means (secondary) that are inferior to others (primary) – while they, actually, could have great value depending on the exact DVI timing. Blau et al. (2023)[8] elaborate on the usefulness of secondary means dividing the human identification process in two parts: one that is based on investigation and the other that is based on evaluation. In the first, finding valuable information for human identification is imperative, such as knowing the sex of the victim. In the second part, the collected evidence can be compared (and with the help of secondary means, the labor-time will be reduced).

The concept of primary and secondary means for human identification comes from the human identification practice in the context of mass disasters (unexpected events that surpass the medicolegal logistics). An interesting fact of the application of secondary means for human identification is that they work as a funnel to narrow down the number of comparisons, speeding the reconciliation process between unknown body and identity. In short, secondary means for human identification will end up in a primary mean if they are used per INTERPOL instructions. For instance, by knowing that from a thousand victims, only three had the same sort of orthopedic prosthesis, AM/PM analyses between ridgeological, odontological or genetical evidence could be reduced up to nine comparisons (AM1 x PM1, AM1 x PM2, AM1 x PM3, AM2 x PM1, AM2 x PM2, AM2 x PM 3, AM3 x PM1, AM3 x PM2 and AM3 x PM3).

When it comes to the secondary means, being unique is not the utmost aspect of relevance for human identification. What matter is the level of distinction of the detected trait to narrow down lists of missing persons. For instance,

tattoos might be a more distinctive trait if found among one or two elderly victims of an accident compared to a situation in which all the victims were young adults. The applicability of secondary means for human identification practice is broad. In addition to the triaging process illustrated in the present review section, authors[8] also have claimed the possibility of re-associating skeletal parts of multiple-victim incidents, by knowing some of the traits of the victims, such as their age (now using forensic anthropology as a secondary mean). Moreover, formal human identification is also claimed by the scientific literature as one of the applications of the secondary means, especially when DNA analysis is not feasible (e.g. due to degradation).

Tattoos as valuable means for human identification

Blau et al. (2023)[8] have demonstrated the usefulness of tattoos for human identification by remembering the Shoreham Air show crash in England, 2015. In the occasion, eleven deaths were registered, as well as 1200 body parts. Tattoos of the victims were used to formulate hypotheses to link body parts and support the human identification process via primary means, namely genetic comparisons.

The Tsunami, in 2004, figured as a major mass disaster in terms of logistics and highlighted once more the importance of tattoos for human identification. Beauthier et al. (2009)[9] in their words stated that "*in this particular case and because of the body conditions the search for scars for example proved to be inadequate, but tattoos however were more easily detected and of great value*". The text illustrates that even under degradation because of exposure to environmental conditions, the bodies still showed tattoos that could help the identification process. The authors[9] add "*the assistance of the local Thai auxiliary personnel in interpreting or translating some of the tattoos proved invaluable*". Since tattoos may carry strong cultural, religious and social components in their art, it is fundamental to understand the circumstances when a body show specific arts. Meanings and styles may change from one region to another.

When it comes to single cases, tattoos also might play a relevant part as a tool (auxiliary or not) for human identification. Santisteban et al. (2022)[10] described a case that happened in Mexico and that consisted of a positive human identification based on personal descriptions of the victim given by alleged relatives. In combination, the relatives reported the presence of four tattoos arts distributed in different anatomic regions of the victim's body, basic information about dental status (i.e. the presence of orthodontic brackets), and sex, age and stature.

Similarly, Granger (2022)[11] reported a positive identification combining tattoos and the dental status of a victim. In their study, the authors did not compare the autopsy findings with the description given the relatives, but instead they used as AM data a picture provided by the family that showed the victim with the same tattoo art

in the exact same anatomic region detected in the autopsy.

The importance of tattoos in forensic science is corroborated by Miranda et al. (2020)[12] after revisiting in deep casework and research on the relevance of tattoo and tattoo inks for human identification. The author encourages an increase on the use of tattoos and tattoo inks in criminal investigations and forensic practice.

Towards the systematization of tattoo registration

One of the aspects that could limit the applications of forensic tattoo analyses for human identification is the scarce scientific background on the topic. However, in order to promote the forensic use of tattoos and enhance the scientific standards, systematic approaches have been developed. A common strategy is to classify tattoo motives in groups based on art styles. This process could help investigators and forensic experts to point out bodies based on more generic descriptions given by the family members. Birngruber et al. (2020)[13] proposed a classification system after revisiting PM records of 2045 bodies from Mexico. The authors established ten tattoo categories:

- *Letters and/or numbers*
- *Human*
- *Symbol (other)*
- *Plant*
- *Symbol (religious)*
- *Animal*
- *Object*
- *Tribal/ornament/geometry,*
- *Fantasy/demon/comic*
- *Other*

Further on the “Special Publication 500-245” the National Institute of Standards and Technology (NIST)[14] proposed via Data Format for the Interchange of Fingerprint, Facial, Scar Mark & Tattoo (SMT) Information (part of ANSI/NIST ITL 1–2000) a classification system based on eight categories of tattoo designs (for each category there is code):

1. Human forms and features (HUMAN), 2. Animals and animal features (ANIMAL), 3. Plants (PLANT), 4. Flags (FLAGS), 5. Objects (OBEJCT), 6. Abstractions, 7. Insignias & symbols (SYMBOL), and 8. Other images (OTHER).

For each category, subclasses have been established to enable a more detailed registration of the tattoo feature:

1. Human forms and features (HUMAN)

1.1. Male face (MFACE)

1.2. Female face (FFACE)

1.3. Abstract face (ABFACE)

1.4. Male body (MBODY)

1.5. Female body (FBODY)

1.6. Abstract body (ABBODY)

1.7. Roles, such as knight, witch, man, etc. (ROLE)

1.8. Sports figures, such as players (SPORT)

1.9. Male body parts (MPART)

1.10. Female body parts (FPART)

1.11. Abstract body parts (ABPART)

1.12. Skulls (SKULL)

1.13. Miscellaneous human forms (MHUMAN)

2. Animals and animal features (ANIMAL)

2.1. Cats & cat heads (CAT)

2.2. Dogs & dog heads (DOG)

2.3. Other domestic animals (DOMESTIC)

2.4. Vicious animals (VICIOUS)

2.5. Horses (HORSE)

2.6. Other wild animals (WILD)

2.7. Snakes (SNAKE)
2.8. Dragons (DRAGON)
2.9. Birds (BIRD)
2.10. Spiders bugs and insects (INSECT)
2.11. Abstract animals (ABSTRACT)
2.12. Animal parts (PARTS)
2.13. Miscellaneous animal forms (MANIMAL)

3. Plants (PLANT)
3.1. Narcotics (NARCOTIC)
3.2. Red Flowers (REDFL)
3.3. Blue Flowers (BLUEFL)
3.4. Yellow flowers (YELFL)
3.5. Drawings of flowers (DRAW)
3.6. Rose (ROSE)
3.7. Tulip (TULIP)
3.8. Lily (LILY)
3.9. Miscellaneous plants, flowers and vegetables (MPLANT)

4. Flags (FLAGS)
4.1. American flag (USA)
4.2. State flag (STATE)
4.3. Nazi flag (NAZI)
4.4. Confederate flag (CONFED)
4.5. British flag (BRIT)
4.6. Miscellaneous flags (MFLAG)

5. Objects (OBEJCT)
5.1. Fire (FIRE)
5.2. Weapons (WEAP)
5.3. Airplanes (PLANE)
5.4. Boats, ships and other vessels (VESSEL)
5.5. Trains (TRAIN)
5.6. Cars, trucks and vehicles (VEHICLE)
5.7. Mythical (MYTH)
5.8. Sporting objects (SPORT)
5.9. Water and nature scenes (NATURE)
5.10. Miscellaneous objects (MOBJECT)

6. Abstractions (ABSTRACT)
6.1. Figure(s) (FIGURE)
6.2. Sleeve (SLEEVE)
6.3. Bracelet (BRACE)
6.4. Anklet (ANKLET)
6.5. Necklace (NECKLC)
6.6. Shirt (SHIRT)
6.7. Body band (BODBND)
6.8. Head band (HEADBND)
6.9. Miscellaneous abstract (MABSTRAC)

7. Insignias & symbols (SYMBOL)
7.1. National symbols (NATIONAL)
7.2. Political symbols (POLITICAL)
7.3. Military symbols (MILITARY)
7.4. Fraternal symbols (FRATERNAL)
7.5. Professional symbols (PROFESS)
7.6. Gang symbols (GANG)
7.7. Miscellaneous symbols (MSYMBOLS)

8. Other images (OTHER).
8.1. Wording (WORDING)
8.2. Freeform drawings (FREEFRM)
8.3. Miscellaneous images (MISC)

In addition to the detailed list of tattoo categories, NIST also developed a system for tattoo colors (the code for each color is given the full color name), namely Black, Brown, Gray, Blue, Green, Orange, Purples, Red, Yellow, White, Multi-colored (MULTI) and Outlined (OUTLINE).

Contributing to the systematization of the process of registering tattoos in the forensic area, INTERPOL has implemented fields dedicated to the description of tattoos based on anatomic region of the body and tattoo style. KMD's PlassData DVI system used by INTERPOL has fields for tattoo records both in the AM (yellow) and PM (pink) forms. On the PlassData AM page 404, for instance, the forensic expert can input information about the presence of tattoos, scars, piercings, skin marks, malformations, and amputations and their respective anatomic region. Yet on and AM

and PM INTERPOL's 400's forms (body description), tattoos are addressed together with piercings and scars, and the system enable the registration of several anatomic regions distributed on the head and neck, toro and limbs. Finally, on INTERPOL's document "AM Data Collection" [15], there are instructions to obtain a detailed description of the physical features of the alleged victim (missing person) and one of them is to request a hand drawn replica of the tattoo (made by the family members, relatives, friends and even tattoo artists that tattooed the person in life, for instance) to help when AM photographs of the tattoo are not available.

Current technology in forensic tattoo studies

Since the early 2000 that technology has been employed in forensic tattoo studies to improve the detection and registration of ink on skin[16-18]. Imaging and image-related technology has been the point of interest of these studies. Clarkson and Birch (2013)[18] demonstrated in their illustrated paper that some tattoos (even the older ones) have enough metallic components that enable their visualization in radiographs. To this end, the authors took radiographs (Faxitron™ 43855C Cabinet X-Ray System, Tucson, USA) from tattooed specimens systematically changing the energy parameters and time of exposure. The authors were able to detect, for instance, traces of metallic materials from red ink on the simulated PM radiographs. In addition, they used infrared light to visualize latent tattoo ink that remain after tattoo removal as well as to visualize original tattoo arts subsequently covered with a new art ("cover-up").

The use of infrared for tattoo visualization in the forensic field has demonstrated that this technology can overcome some of the thanatological body alterations, such as skin discoloration, that could jeopardize conventional photography[16]. Starkie et al. (2011)[16] tested infrared reflectography on a tattooed piglet carcass during a follow-up of 17 days. Despite the mumification and skin discoloration, a proper visualization of the specimen's tattoos was optimally feasible. More recently, Cullip et al. (2021)[19] endorsed the contribution of infrared light applied to the forensic field for tattoo visualization. The authors reported a case of a drowned victim that was found submerged after ethanol intoxication – on which a tattoo that should be on her shoulder was not visible. Cross-polarized lighting and infrared photography were used as auxiliary resources and end up being decisive to detect the tattoo.

Changing from image-related to chemical-related aspects of tattoo investigations, it is worth mentioning that some studies have profiled tattoo inks to understand their biochemical structure and safeness for humans[20,21]. The fact is that profiling tattoo inks based on their composition might be beneficial as well for forensic applications. The Danish Environmental Protection Agency[22] developed a study with 61 tattoo inks and detected amounts of Chromium and Nickel in in hazardous concentration in some of the specimens. From a clinical perspective, these compounds are relevant because

they may trigger adverse reactions. From a forensic perspective, knowing that some inks have specific substances while others do not could be relevant to distinguish inks, and maybe tattooed individuals.

DISCUSSION

The relevance of tattoos in the forensic field can be related to the identification of the living and the deceased. The former encompasses the investigation of tattoos observed in crime-related individuals, such as inmates, criminals captured in close-circuit TV cameras or pictures[23], and even among victims of human trafficking and sexual slavery. In this context, tattoo designs could help finding potential associations of individuals and criminal organizations, for instance. When it comes to the application of tattoo analyses to support the identification of the deceased, a comparative analysis between AM and PM data is required. In order to compare, however, proper image registration and description of the tattoo is needed. Ideally, AM data should be as clear and recent as possible to enable adequate visualization of the tattoo. The best scenarios include the availability of AM good quality photographs and video recordings of the victim showing the tattoo. In challenging circumstances, on the other hand, image records may not exist – leading to the alternative use of verbal or graphical (drawings) descriptions given by the family members.

The use of tattoo descriptions provided by those who claim the body is assured by INTERPOL as a possibility to gather comparable information[15]. Hence, the forensic professionals involved with the analysis of tattoos should be aware of the current INTERPOL recommendations, as well as technological possibilities and classification systems available to make sure that they can approach the evidence optimally. An important question emerges at this point: "*Who are the proper professionals to handle and manage cases that involve the forensic analysis of tattoos?*" This is clearly a jurisdiction-based question and in this section will be addressed following the Brazilian standards. Because tattoo analyses start with the detection of tattoos on the deceased, professionals that work directly on the cadaver could be considered first. In Brazil, the experts that work with human identification in medicolegal institutes (not related to laboratorial analyses in Criminalistics institutes) are usually physicians and dentists. Some of the tattoos, such as those on the face, are even more related to the field of work associated with dentistry (focused, but not restricted to the head and neck region). Other professionals that could work properly with the registration and analysis of tattoos are forensic anthropologists, but at this point it is worth mentioning that Brazil does not have a bachelor's degree in forensic anthropology neither an official position such as "anthropologist" in the Federal and State forensic services. However, recent training at specialization level has been offered and all the selected applicants were dentists[24]. This phenomenon reflects the participation of dentists not only with cases that concern dental human identification, but also in cases that require

anthropological knowledge and assessment of the cadaver's full body for PM examinations. Since experts that work with anthropology are not restricted to the examination of the deceased and are gradually more skilled with imaging analysis of the living, it is worth considering that dentists would be proper analysts of tattoos for human identification in Brazil together with medicolegal doctors.

A step further into the field of forensic tattoo analysis could be construction of a national image database. In the United States, for instance, NIST launched in 2014-2015 the Tatt-C (Tattoo Recognition Technology Challenge) program[25]. This project started with a database of the Federal Bureau of Investigation (FBI) containing 15.000 images of tattoos from prisoners[25]. Together with 19 organizations, algorithms were developed to detect the presence of tattoos from pictures and to reconciliate different tattoos from the same individual.[25] Accuracy rates were above 90%, and the MorphoTrak Inc.™ (Anaheim, CA, USA) solution was ranked the best for these tests.[25] The construction of databases in Brazil, however, would face some of the challenges currently faced in USA, namely the use of personal information for legal purposes. Some tattoos are not only distinctive because of their art style but also because they contain names, birth dates and other relevant personal data that could reveal the identity of its owner. Hence, having individual consent to record a tattoo art and use for any purpose is of extreme importance, in addition to the fact of being time-consuming.

In parallel to the development of databases, training must be encouraged in the field of forensic tattoo analysis. Currently, this field is scarce of courses and advanced education. Most courses found on-line are embedded into bachelor's degree in criminal investigations and forensic sciences higher education. Examples include the course "Tattoo & Forensic Investigations" by Dr. Michelle Miranda at the Department of Criminal Justice, Farmingdale State College. The basic knowledge to be delivered in specialized courses should cover, but not being restricted to the topographic anatomy of the human body, forensic photography, tattoo art and culture, biomechanics of tattooing, basic dermatology, biochemistry applied to tattoo inks, biometrics, and case-based learning. Moreover, with the advances in research on artificial intelligence[26], experts will need soon training not only on the traditional description and registration of tattoos, but also on machine and deep learning applied to comparative analyses.

FINAL CONSIDERATIONS

Compared to other field of the Forensic Sciences, forensic tattoo analysis seems to be in the beginning of a productive journey towards human identification. The field is gaining space quickly with studies that explore the interface of modern high-tech devices for chemical and photographic analysis applied to the ancient art of tattooing. Tattoo classification systems, biometric algorithms and the development of large image databases appear as cornerstones to the

development of the field into a more scientific and reliable method to support human identification. Predicting the need for specialized knowledge, forensic experts must seek for training in order to be prepared to serve the Justice optimally. Strategies to incorporate forensic tattoos analysis into official training programmes should be structured not only in the form of short- and long-term continuing education courses, but also when experts are initially trained inside the police academy.

RESUMO

A identificação de vítimas de desastres em massa é estruturada de acordo com recomendações internacionais na tentativa de otimizar a logística forense. A INTERPOL (*International Criminal Police Organization*) estabelece métodos primários e secundários para identificação humana. Este estudo teve como objetivo revisitar a literatura existente para abordar a importância forense das tatuagens. A literatura científica tem mostrado avanços nas análises forenses de tatuagens, especialmente no que diz respeito à aplicação de técnicas especiais de imaginologia, como a fotografia com luz infravermelha para visualizar tintas latentes de tatuagens e tatuagens de cobertura, bem como a utilização de processamento bioquímico para distinguir componentes das tintas de tatuagem. Outro aspecto relevante são os campos dedicados à descrição de tatuagens em softwares utilizados mundialmente para identificação de vítimas de desastres em massa, como o PlassData. Sistemas de codificação também foram propostos para facilitar a comunicação no processo de identificação humana. O futuro das análises forenses de tatuagens é promissor considerando o aumento das pesquisas nos últimos anos. A prática forense pode beneficiar-se com mais evidências científicas para apoiar a utilização de análises de tatuagens na condução de casos periciais.

PALAVRAS-CHAVE

Odontologia legal; Medicina legal; Identificação humana; Tatuagem.

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