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FORENSIC ANTHROPOLOGY FROM INDIVIDUAL IDENTIFICATION TO PERSON IDENTIFICATION. A REVIEW

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Abstract: Forensic anthropology emerges from the ground centered on skull examinations which were told to give answers to all questions. Identification was the paramount task in front of any anthropologist. Then the skeleton came into interest of the forensic anthropologist as the inflicted trauma lesions examination and taphonomy develops. Forensic anthropology followed a long road from anthropologists such as Lacassagne or Minovici in late 19th century until the recently use of stable isotopes in the late decade. Several historical periods were stepped on. Whenever the forensic anthropologist is a forensic doctor specialist born in legal medicine or an anthropologist with legal medicine competence, forensic anthropology examination need interdisciplinary teams for broadening expertise and competence. We no longer call forensic anthropology a physical specialty because even if the tasks gravity around the human remains, all modern technologies, i.e. micro-XRF, micro-CT, stable isotopes, spectroscopy, etc., allows reconstitution not only of the physical elements of a dead individual but of a living individual, receiving a physionomy, a way of life and finally, a name and a model of consciousness to rebuild and recover the person of the deceased individual. Therefore, another paradigmatic change has moved anthropology with its tasks and methods from individual identification to person identification. Modern values in forensic anthropology and generally speaking on anthropology mirror the moral values of the scientific European space in 1937 made vocal at the tribune of the 17th Congress of International Anthropology in Bucharest, a rare paradox for a Congress of anthropology in an European space full of eugenics where the great force of science and reconciliation suppressed all negative concepts and behaviours. We could define forensic anthropology as a medical specialization that, at the request of justice, aims to identify all human remains, the circumstances in which those individuals died and lived to conclude finally to a person identification.

Key words: forensic anthropology, micro-XRF, micro-CT, Fourier spectroscopy, stable isotopes, identification of the individual, identification of the person, rebuilding and recovery of a person.

INTRODUCTION

Etymologically speaking, anthropology comes from the Greek word "anthropos", which means "human being", and logos - "speech", that is, the study of humans. Within biological anthropology we have forensic anthropology, which focuses its study to also meet the demands of justice as a specialization with a pronounced applied characteristic; it makes use of modern technological developments to analyze decomposed human bodies or their remains, especially from the perspective of establishing their identity [1].

Forensic (physical) anthropology collaborates with forensic pathology (the study of organic and traumatic injuries), forensic archeology (methods of identifying, excavating, protecting and preserving forensic artifacts), forensic taphonomy (the study of post-mortem changes of the human body subjected to the action of the environment and animals), forensic dentistry (the study of the medical aspects of the masticatory apparatus in order to identify a person) in order to determine one's sex, age, height, their date, cause and circumstances of death, their identity, the diseases they suffered from, but also their eating and life habits, where they lived, or if there were traces of violence or traumatic injuries suffered before, during or after their death.

"Dead people will tell their story" - an old aphorism born when in 1889, at the very beginning of forensic anthropology [2], Alexandre Lacassagne, a professor of forensic medicine in Lyon, solved, like a "French Sherlock Holmes", a murder where the unidentified dead body was cut into pieces. During the same period and with the same intensity, in Romania

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professor Mina Minovici was leading the development of forensic anthropology within the forensic medicine specialization [3, 4]. After about 100 years of forensic anthropology, in 1988, professor Mehmet Yaşar Işcan wrote in a scientific article for a large professional audience that forensic anthropology arose from the need of the medical and legal systems to determine the characteristics of an individual; and that this specialization, as it's in a development process, needs scientific proofing methods so that "the role of the forensic anthropologist is fully understood and accepted by both the anthropological scientific community and the forensic one". [5].

Professor MY Işcan's clairvoyance was confirmed and the development of molecular biology techniques in close connection to the legal system counted as a decisive step in the identification of a person; this was a valuable aid for forensic anthropology but did not replace it: thus the DNA analytical methods, especially PCR (polymerase chain reaction), as methods of amplifying the infinitesimal amounts of DNA that can still be found in altered bone fragments, have led to the development of judicial genetics [6].

However, jurisprudence requires that the methods and investigations provide scientific results which are reliable [7, 8], have been tested and scientifically peer reviewed [7, 8], have a presentation of the error rate, can be "acceptable" and, furthermore, have a "general acceptance" [8] within the scientific community which is then accountable for them (Daubert *vs*. Merrell Dow Pharmaceuticals (113 S. Ct. 2786) [7].

In Romania, professor Mina Minovici (1892), followed by professor Nicolae Minovici (1918) and their forensic schools started a complex education of forensic anthropology within the forensic medicine profession which still continues today, as the forensic anthropology course is part of the mandatory curricula for the forensic medicine specialization.

The development stages of forensic anthropology worldwide

In our opinion, one can summarize two development periods for forensic anthropology: a historical period and a modern period.

The historical period begins in the early 1890s. Through his entire professional activity professor Mina Minovici closely connected legal medicine and forensic anthropology as a subspecialty of legal medicine. In Romania this historical period was institutionally supported from the beginning by the activity of the Institute of Forensic Medicine from Bucharest, founded by professor Mina Minovici in 1892. His scientific views were critical on the Lombrosian theory, on "moral madness of the criminal" and on the "stigmas of the inborn criminal" and well-known [9]. He did not shy away from talking from the dais of the International Anthropology Congress about his scientific reservations regarding the Lombrosian theory; as such, he was not a supporter of eugenics. He said, "According to Lombroso, criminals have a stigma of degeneracy which would allow to identify them in advance. Well, I have not come across any of these stigmas." [10].

On March 15, 1892 in Bucharest professor Mina Minovici set up the anthropometric service as a unit of the Ministry of Justice and the criminal record ("Catalog of convicts from all over the country"). Between 1892 and 1896 he undertook a comprehensive anthropological study on 7,217 cases (5,980 men, 494 women, 743 children, with a total of 20 ethnic groups), applying the Bertillon system of identification based on anthropometric measurements. He followed up on some of these cases after the death of the subjects as well: he methodically, scientifically and anthropologically analyzed the anatomical landmarks of various criminals' bones and skulls; he also did an evaluation from a broader ethnic and anthropological perspective, putting together the second largest

anthropological collection in the country after professor Francisc Rainer's one. Both collections can be studied today at the Fr. Rainer Institute of Anthropology and, respectively, at the museum of the National Institute of Forensic Medicine Mina Minovici in Bucharest.

Professor Nicolae Minovici, as the director of the anthropology and identification service, continued his older brother's research [11] but also supported, in the early 1900s, the development of dactyloscopy and of the identification of dead bodies by reconstructing their facies (including the prosthesis of the globes) and photographing them afterwards. But perhaps the apex of the importance Romanian forensic anthropology had in this historical period was professor Nicolae Minovici hosting the International Congress of Anthropology and Prehistoric Archeology in 1937, as the scientific secretary of the Congress. That year he brought to Bucharest all the representatives of the anthropology schools in the world, who gathered around his personality supported by his professional value, his renown and visibility in this field; thus, benefiting from the backing of the Romanian government and the royal crown, he successfully organized a convention that will remain forever in the history of this world event.

Professor Francisc I. Rainer (1874-1944) remains the most representative figure of Romanian anthropology as the founder of the anthropological school. Benefitting from the peak moment of the historical development of Romanian anthropology, the International Congress of 1937, in 1940 Francisc I. Rainer established the Institute of Anthropology as an autonomous institution, next to the University of Bucharest. He organized there the largest collection of skeletons and skeletal remains in Romania, over 6,300 artifacts with all the anthropometric data listed.

Professor Mina Minovici (since 1892), followed by professor Nicolae Minovici (from 1918) and their forensic schools, started a complex training and formation of specialists in legal medicine and forensic anthropology which still continues today: forensic anthropology is part of the curricula for the forensic medicine specialization.

Courtesy of the Fr. I. Rainer Institute

As a result, in our country forensic anthropology as a subfield of forensic activity was practiced by experts trained at the National Institute of Forensic Medicine Mina Minovici Bucharest as a center of excellence since 1890 by professor Mina Minovici (1857-1933), professor Theodor Vasiliu (1897- 1961) [12], Dr. Cantemir Riscuția (1923-2003) [13], professor Viorel Emanoil Panaitescu (1938-2017) [14], but also at the Cluj-Napoca Forensic Institute starting in 1919 with professor Nicolae Minovici (1868-1941), then professor Viorel Kernbach (1895-1976) a member of the team of anthropologists attributed to investigate the Katyn massacre (1943), as well as at the Iasi Forensic Institute with professor George Bogdan (1859-1930), who built the foundations of the institutional destinies of forensic medicine in Moldova.

The modern period worldwide begins in the 1970s, when forensic anthropology is relaunched as a physical biological science, a scientific subfield either within forensic medicine or detached from it, once the importance of subspecialization and advanced training for forensic anthropology experts is recognized. The modern period has in turn several development stages [15].

The first stage was the development of quantitative methods. In the USA, the involvement of the justice system as the beneficiary of forensic results and opinions was achieved by supporting facilities such as the Anthropology Research Facility (ARF) to study the decomposition of the bodies or by putting together extensive osteological collections such as that of William M. Bass (over 600 persons) or, over a decade, the Terry Skeletal Collection (BSC) with over 1,600 people; all this led to the set up of a large forensic database, the Forensic Data Bank (FDB) which led to the development of the field through discriminative analysis. The BSC is an essential component of the FDB and was started in the US in 1986 by the National Institute of Justice (Jantz and Moore-Jansen, 1988) [15].

Modern means of investigation are added to the study of forensic anthropology and they provide details, data and information useful for the justice system; an example is Fordisk, which lets one compare data with known racial, ethnic, age, sex, and other profiles, using the analysis of discriminative functions. Fordisk uses multivariate statistical techniques (Jantz and Ousley, 1993, 2005; Ousley and Jantz, 1996), a discriminative analysis based on data provided by the FDB and compared with measurements of unknown persons to be identified. Over the past 30 years, starting with 1990, empirical results on single or multiple persons have led to the verification and completion of the FDB data [15].

A second stage was represented by the development of forensic taphonomy, which changed the paradigm in forensic anthropology [16]. Through taphonomy, forensic anthropology has changed from a laboratory discipline into a clinical, scientific discipline; forensic anthropologist experts have enriched their forensic medicine knowledge and vice versa, and all combined their expertise with that of an investigator within a complex team professional investigators also belong to.

Efremov (1940) seems to have been the first to use the "forensic taphonomy" phrase, which was later associated with archeology (Grayson (1984) and paleontology (Klein and Cruz-Uribe, 1984); it truly developed between 1960 and 1980 when studies of sampling (Boaz, Behrensmeyer, 1976), transportation (Voorhies, 1969; Wolff, 1973), conservation (Behrensmeyer, 1978), in situ (Patterson *et al.*, 1970; Isaac *et al.* (1971), or statistical comparative analysis could be carried out. Whenever people become taphonomic agents themselves, the study of the resulting taphonomic effects becomes a goal of forensic anthropology; this is not only to understand the phenomena, processes and methods that have been used to alter human remains, but especially as a vehicle to understand human behavior [17].

What we today call post-mortem evaluation or analysis of skeletal remains is in fact applied forensic taphonomy. Forensic taphonomy is thus defined as "the use of models, approaches, and analyses in a forensic context to estimate the time elapsed from death, to reconstruct the circumstances before and after the body was placed, and to differentiate the products of human behavior from the natural ones". (Haglund and Sorg, 1997, p. 3 [18]).

From a taphonomic perspective, forensic anthropology, beyond the identification of the person/ persons, has gained 3 goals of taphonomy itself: (1) the estimation of the post-mortem interval (through the analysis of decomposition, the use of physical, chemical or entomological investigations), (2) the reconstruction of the initial position and orientation of the body at the time of death and (3) the evaluation of the role of human intervention (a person as a taphonomic agent) or of any other natural causes on the stripping away of human remains (Gifford 1981, [19]).

The third stage may be represented by the development of forensic archeology (practical taphonomy). MY Işcan was also talking about forensic archeology when he was presenting the "archeological site from the scene" ("Crime Scene Archeology", 1988) and was recommending mapping the place of discovery [6].

In 1982 Snow said that "the spatial distribution of bones, teeth and other items that are recovered from the scene can provide information about the initial placement of the body and suggest its initial position" [20]. Locating the crime field or crime scene using GPS or electronic total stations is a basic technological approach today [21]. Conceptually it is considered that all the materials that are found at the site where the corpse is located are part of the forensic anthropological material evidence of that site [20, 21].

The fourth stage in the development of forensic anthropology was the systematic investigation of the traumatic lesions of the skeleton, taking into account the following aspects: (1) anthropological investigation of skeletal remains using (or not) the knowledge of the forensic pathologist, (2) biomechanical aspects of the bone as well as microscopy as a basic study method (3) anthropological taphonomy.

Consequently, the forensic anthropologists managed to find their place on the team of the forensic pathologist using their knowledge of anatomy, biomechanics and criminology. Of course, anthropologists can themselves be forensic pathologists with prior training and extensive knowledge (Smith *et al.*, 1990 [22]; Symes and Smith, 1998 [23]; Galloway *et al.*, 1999 [24]). This would be an advantage from the expert perspective as one person would have access to such complex, varied and multidisciplinary knowledge as that of forensic medicine and forensic anthropology.

The role of the forensic pathologist and of the forensic anthropologist with extensive knowledge of forensic medicine is highlighted at this stage of the development of anthropology. The field gains knowledge which is absolutely necessary to approach the conclusions of the experts' trauma opinions on skeletal remains [25-28].

Also during this stage the anthropological forensic analysis approached the children and the elderly differently, establishing characteristics regarding the age of the individual, the occurrence of injuries and especially the evolution of the corpse in time, that is, its perimortem (antemortem, during death or postmortem) nature and of the trauma (pre-trauma, during trauma or post-trauma) [26].

A correct interpretation of traumatic injuries should take into account the lesion aspects and the victim themselves with their diseases, age, sex but also the taphonomic elements, such as the human activities that caused the injuries or the period after their occurrence, including death following human intervention, the action of nature or both. Forensic archeology together with taphonomy are thus both important to create a correct approach that reconstitutes the circumstances of the victim's laying down on/in the ground.

The fifth stage is important and still ongoing as the stage of forensic anthropological casuistry and of the development of the study of stable isotopes [15].
It has been undergoing two historically intricate sub-stages:

(1) the casuistry period when suspicions were raised regarding the violation of human rights (e.g. the investigations undertaken by the Doretti forensic anthropology team in the 1980s or the anthropological investigations in cases where there were suspicions of precipitate burials in mass graves, i.e. the mass graves in Kathyn in Poland in 1940, Argentina in 1976-1983, which led to the foundation of the Argentine Forensic Anthropology Team in 1986, etc.).

(2) the casuistry period of war conflagrations and terrorist attacks.

The forensic value of the artifacts in these cases can be diminished by the absence of contextual information, which in turn affects the work of the case prosecutors [15]. An archaeologically correct approach of a case increases the chance of taphonomic reconstructions that would allow for the identification and preservation of evidence; this in turn leads to the final identification of the victims through DNA (or other forensic methods) and of the traumatic injuries by the forensic pathologists involved. (Tuller *et al.*, 2008 [29]).

The analysis and interpretation of the scene where a fire or arson took place and the analysis of the resulting trauma is an example of the importance of correlating forensic archeology and forensic taphonomy with the examination of specialized teams of investigators, among whom the presence of forensic pathologists is compulsory. (Mayne Correia, 1997 [30]; Mayne Correia and Beattie, 2002 [31]), Schmidt and Symes, 2008 [32]).

Anthropological investigation has two goals in these complex cases: (1) identification of bone fragments with or without soft parts (2) forensic interpretation of the lesions from the perspective of the moment of the arson perimortem or which occurred due to arson or the action of the fire, as well as the differentiation between pre-existing lesions and those that appeared during the aggression or after death. Identifying, lifting, transporting and preserving burned human remains is very difficult: often these fragments are fragile, wet due to the fire fighters' intervention, and contaminated with various flame retardants or substances that set off the combustion, which are not at the fire scene, and are often without proteins due to the action of the fire at temperatures above 200 degrees Celsius; this greatly reduces the possibility of DNA protein identification [30, 32].

To determine the number of victims is becoming increasingly important, especially in regard to their subsequent identification. Thus, for identification purposes, the anthropological examination precedes the DNA analysis; it also involves differentiating between traumatic lesions that have a high forensic significance (perimortem lesions) and those that have a lower forensic significance (the post-mortem or burn injuries, as the case may be).

Ah, the isotopes ...

In October 2000, in Utah, near the Great Salt Lake, some hunters found 26 bone fragments, some blond hair stuck to a skull and a few clothes. A search to identify the missing person begins under the name "Saltair Sally". Beyond the anthropological landmarks of female, about 20 years old and blond hair, the anthropological identification stagnates [33].

Seven years later, in 2008, a method developed at the University of Utah discovers the possibility of identifying stable isotopes and their ratio (in this case of H and O in water) as well as the role they play in establishing the deceased's residence, migration and reconstitution of their way of life. [33-37] It is decided to use the blond hair for an isotopic analysis. The time of flight method is used in a mass spectrometer with secondary ions (TOF-SIMS) at Salt Lake City-based IsoForensic. This becomes the first case of forensic anthropological investigation of stable isotopes [33].

A drop of water from the clouds above the Pacific coast usually contains O-18, a heavier isotope of oxygen, so the fresh water that these coastal populations drink is loading O-18 into the body of those inhabitants. The clouds above the land, however, contain lighter oxygen, the lighter the more we move away from the coast, because the water droplets are smaller (O16-O11). It is thus discovered that during the last 2 years Saltair Sally migrated between the coastal region and the inland several times [33].

As per the isotopic structure and the isoscape of the girl's hair, in 2012 the Salt Lake police requested the public's help in identifying a young blonde girl who migrated in the last two years of her life with a travel pattern of repeated trips between the coastal region (Seattle) and the inland (Saltair); this eventually led to the identification of the missing person as the 20-year-old Nikole Bakoles, later individualized and confirmed by DNA testing her mother and the skeletal remains found in Saltair [38].

Each atom contains protons and neutrons. The number of protons defines the element (H, O, C, N, Sr, etc.), the number of neutrons defines the isotope, and the sum of the protons and neutrons defines the atomic mass of an element. For example, C has 6 neutrons and 6 protons and is listed as C12. 1% of the Earth's carbon contains 6 protons and 7 neutrons and represents the heavy carbon C13, a stable isotope. C14 contains 6 protons and 8 neutrons, is radioactive and thus unstable. By measuring the amount of the radioactive isotope C14 found in a plant or in a bone fragment, one can determine the age of the plant or of the bone, given that the half-life of C14 by decay is of 5,730 years; thus the dating period extends practically between 500 and 50,000 years.

Stable isotopes, unlike radioactive ones, have a stable nucleus that does not split. In the last ten years, the use of stable isotopes in modern anthropology has gained a special value and importance through the development of a new field of investigation which has proven to be unimaginably fruitful both in scope, but also in the results it can offer to reconstruct the biological profile of a missing person and their social and individual characteristics (age, sex, height, descent, old traumatic aspects, malformations, etc.) [39].

The ratio that is established between the stable isotopes of the same element varies in different substances (e.g. water or food) or between different ecosystems (e.g. dry land/ sea, temperate/ northern climates, etc.).

Not only stable isotopes but their ratio also is incorporated into the human body through one's way of life, with variations according to the different tissues. It is thus possible to establish a link to the environment and to place a person in a certain environment (geolocation). On the other hand, isotopes enter our tissues at specific times in relation to our ontogenetic development, so identifying them and especially their ratio can allow for very accurate dating of the duration of life and of the period from the present moment to the moment they were incorporated in the body under investigation. [40].

The isotopic signature of the teeth never changes, that of the bones changes very slowly (20-25 years), that of the muscles faster (3-6 months) [41].

The most commonly used stable isotopes are the following [40]:

- Carbon isotopes C (C-13) or C (C-12) and their C/C ratio called δ13C (delta-13-C) to determine the type of diet based on wheat or corn. Carbon is reflected in the diet it reaches from the plants that take in atmospheric CO2. Thus, C3 is found in a diet based on wheat, rice, and sugar beet, while corn, sorghum, and sugar cane contain C4 and high levels of C-13 [40].
- Nitrogen isotopes N (N-15) and N (N-14) and their N/ N ratio called δ15N (delta-15-N) for diet (e.g. consumption of fish or animal meat) or the moment of natural dietary diversification. Similar to carbon, the nitrogen reflects the diet it reaches from the meat of animals and also from the plants these ate during their life. Nitrogen varies if the person is omnivorous, vegetarian, or vegan, with an N-15/N-14 ratio increasing by 3.4% with maximum N-15 values in vegans [41].
- Oxygen isotopes 18O (O-18) and 16O (O-16) and their ratio (18O/16O), called δ18O (delta-18-O) are used to determine the pattern of fresh water consumption. The isotopic composition in H and O (bones and hair) can be related to the values of δ2H and δ18O of the water intake, either direct (drinking water) or indirect (food) [42].
- Strontium isotopes 87Sr (Sr-87) and 86Sr (Sr-86) and their ratio (87Sr / 86Sr) is used to determine migration [40]. C (δ13C), N (δ15N), S (δ34S), because they provide information on a person's diet, also allow for geolocation, the so-called "trophic level effect" [43,44].

The multi-isotopic (C, N, O, H, S, Sr, Pb) profiles are increasingly used; the same is true for the isoscapes obtained from several tissues: teeth (usually from molar 1 if it is available), bones (rib, femur), skin appendages (hair, nails) in order to determine a person's region of origin, of residence, their diet or their recent travel history [41].

As for the tissues and the variations of the isoscapes in relation to them, the following could be observed:

Hair and nails provide diet and residence information. Hair and nail keratin is often used to get a geolocation of a person as well as information on their eating habits (fingernails increase by about 2-3 mm/ month, toenails by 1mm/ month and hair by 0.4 cm/ month) [45, 46].

The ribs can provide information on one's residence and diet in the last 5-10 years of life while the femur from the last 20-25 years [41,47].

Unlike the carbon isotopes from the bone collagen which is impregnated by the evolution of the proteins, the bioapatite (teeth) is formed from the bicarbonate dissolved in the blood and as such gives information on the consumption of carbohydrates, lipids and proteins that are not used in the collagen synthesis in the bones, thus reflecting one's entire diet type [48].

In order to carry out the tests, however, the samples must be converted into simple gases, e.g. H for H2, C for CO2, N for N2, O for CO, and S for SO2: this way the isotopic ratios of the bio-elements can be measured using mass spectrometers that measure the isotopic ratio IRMS [49].

On the other hand, the methods used to prepare a biological sample and to analyze it can have an impact on the resulting isotopic values. About half of the isotopic variability is due to differences in sample preparation and the other half to analysis techniques: that is why the laboratory which analyzes the samples is very important [49].

Decayed bones and especially decaying methods which include combustion and exposure to high temperatures with or without initiators of combustion raise even more forensic problems, not only related to identification but also to taphonomy and establishing the circumstances of death, sometimes with critical value in judicial investigations.

An important issue in forensic medicine is of course identifying a deceased person, especially when their body has been subjected to the action of increased temperature. One can search for the nuclear DNA, find a DNA profile and then identify it by comparing it with other profiles from that person's relatives, using to this purpose the maternal and paternal alleles in the nuclear DNA; one can also search for mitochondrial DNA by using maternal kinship. Any of these methods, however, requires protein, and an increased temperature, bad weather conditions or bacteria create conditions that lead to a sometimes dramatically decrease in successful DNA testing[50].

It is difficult to find DNA in bones that were subjected to high temperatures, that is, above 200-210 degrees Celsius, an aspect confirmed by many researchers; according to some, it is even absent if the bones burn at over 200 degrees for 45 minutes [51] or when the skeletal remains are subjected to over 210 degrees Celsius for 2 hours; thus the percentage of identified DNA in burned bones or especially in those subjected to complete cremation is drastically reduced beyond the limit of 200 degrees Celsius [52].

Even if they are burned, sometimes up to complete cremation, the bones have on their surface various elemental substances that come either from the bone structure (often Ca) or they are contaminating substances from the environment in which the burning took place (buildings, pits, etc.), their walls or from the different materials used either to start or keep the fire burning or which are accidentally found in those circumstances. The test that can identify the elemental substances from the bone's surface or superficial layers is micro X-ray fluorescence (μXRF). The micro X-ray fluorescence measurements let one map the composition of the substances found on the various surfaces of the objects identified in the investigation of the scene, the site where the human remains or the skeletal remains were found [53-58].

It should be highlighted that the μXRF method allows for the identification of elements with a higher atomic number than that of the silicon. The EDX method performed with SEM is used to identify elements with an atomic number lower than that of the silicon. The EDX also identifies the light elements from the category of Al, Mg, Si, etc. The elemental composition identified through μXRF must be corroborated with that identified through EDX (independent measurement performed with SEM).

The results of the micro X-ray fluorescence measurements are presented as tables that include fluorescence energetic spectra, photographs of the samples with the location of the examination area and the quantitative elemental composition.

The identification of a similar elemental composition or even similar on different burned bone fragments, especially when there are rare elements that are not usually found in bones (e.g. Ti) or in a natural environment, indicates similar taphonomic circumstances.

A basic component of the bone is the calcium phosphate called bioapatite. Subjected to the action of temperature, the bioapatite is converted to hydroxyapatite, where hydroxyl groups replace some carbon atoms and couple phosphate groups. As a result, the burned bone presenting with hydroxyapatite following the FTIR analysis of the collagen absorption bands from the bone structure [58] is relatively easily identified; it is possible to verify its age and also the burning temperatures it was subjected to.

The burning temperatures, the postmortem interval [59], and the composition of the bones [60] or of the substances on the surface of the bones if they appear to be organic substances are identified by the Fourier-transform infrared spectroscopy method, FTIR [61].

The structural volume analysis with X-ray microtomography (XCT) is another very useful analysis that allows for a detailed scan of bone fragments or skeletal remains, including burned ones, and for the identification, within them, of the regions where collagen or proteins may still be present to be extracted through microdissection [62]; they can then be tested for DNA or other particles which have judicial value or can help with the identification or the taphonomic circumstances related to the death. The method allows not only for in-depth scanning but also for an often spectacular 3D reconstruction of the bone fragments and for the comparative analysis of several samples.

The micro-scanner lets one scan with a spatial resolution below 20 microns/ pixel. This allows for a qualitative analysis through a visualization of all the morphological details, the effects of the damage from the burning and the possible perimortem trauma.

The quantitative analysis allows for the dimensional and density evaluation of the elements that constitute the bone fragments, and as such for the species diagnosis through the analysis of the Haversian systems of the bone.

The modern concept of forensic anthropology

The stages described here are of course chronological; they mark a chronological succession of the development of forensic anthropology, but also the need to have interdisciplinary teams and to broaden the expertise and competence in the specializations that are called to work together to anthropologically reconstruct the period that followed a person's death, how and in what circumstances that death occurred, and that person's life beforehand.

What is interesting to note is that the anthropological reconstruction process, which generally focuses on a person's skeletal remains, also includes the persons who performed taphonomic activities in relation to the subject of the study; so forensic anthropology in its modern meaning reconstructs not only a person's death and life, but also data and information on others who may be either within the criminal field or outside of it.

Thus, we would no longer call forensic anthropology a physical specialization only; even if it is centered around one's human remains, it will lead to the reconstruction not only of their individual or physical elements, but even of the deceased person itself, providing them in the end with a face, a name, a way of life and, finally, a model of consciousness. In other words, the stages described in the previous section are not only historical stages in the development of this specialization but a continuous process of its development.

In the development of forensic anthropology, the concept of analysis of human remains has been expanded and it has gone from an analysis of the bone fragments that are discovered to an anthropology of the missing body, then to the reconstruction of the person who is deceased and in the end, through abductive reasoning, of the (taphonomic) circumstances in which that person's death occurred.

We thus leave behind the concept that forensic anthropology is a laboratory specialization and now develop the concept according to which forensic anthropology is primarily an anthropological specialization that tries to reconstruct the person of the deceased, their way of life and the circumstances of their death, using an abductive approach through a reconstruction from the moment the human remains were discovered to the moment of death, or even to the period before death.

From MY Işcan's definition of forensic anthropology as "a science of a subfield of physical anthropology" (MY Işcan, 1988, [6]) we have evolved to a definition where "forensic anthropology involves applying principles used in the anthropological subfields of archeology and physical anthropology to forensic investigations" (Dirkmaat and Adovasio, 1997 [49]), and then to a broader definition according to which "forensic anthropology is a science about life, death, and a person's after life period as reflected in their skeletal remains and in the physical, forensic and legal context in which they are found" (Dirkmaat *et al.* 2008, [63]).

Even so, we acknowledge that the aforementioned definitions do not yet fully reflect the value and purpose of the forensic anthropological approach.

We could define forensic anthropology as a specialization that, at the request of the justice system, aims to lead to the identification of human remains, to reconstruct the deceased person or persons, the circumstances in which they lived and died and the circumstances of their death.

In order to achieve these objectives, forensic anthropology has been subdivided into a number of subspecializations or subfields of activity: physical anthropology, forensic taphonomy, forensic archeology, forensic paleoanthropology and of course, forensic anthropology itself.

The development of complex anthropological investigations and analyses allows for diagnoses that seemed inconceivable 20 years ago, even more so 50 or 100 years ago. 123 years passed since professor Lacassagne, in 1889, found human remains wrapped in a cloth bag and by anthropological identification methods proved them to be Gouffé's, to when the skeletal remains found in a plastic bag were identified through the stable isotopes of fresh water drunk in the different places where she had resided in the last two years of her life as those of Nikola Bakoles. Nothing that was useful 123 years ago is abandoned or useless today, so that it continues to be at the foundation of forensic physical anthropology.

On the other hand, new technologies add today what was invisible yesterday to the eyes of professor Lacassagne, the famous anthropologist of the 19th century. The integration of 4D platforms for a detailed anthropological and forensic investigation, especially of thermally exposed and burned skeletal remains, which combine the results from micro-XRF and micro-CT methods in portable equipment that can be used while on the ground can be seen as progress on the horizon of current technology, as they save time during an investigation.

We are witnessing the transition from physical anthropology to the modern, psycho-socio-physical one, from the identification of the individual to the identification of the person.

In recent years, a series of studies involving the forensic anthropological examination of thermally exposed and burned skeletal remains have gained notoriety due to criminal cases, accidents, terrorist activities, natural disasters or calamities and catastrophes. The anthropological examination of the burned skeletal remains raises additional problems which are unfortunately still current, given the increased incidence of terrorist attacks.

Thus the recovery of bone fragments and skeletal remains, the chain of custody [64], the anthropological reconstruction [65], the bone recognition [66], the anthropological identification that precedes the DNA examination [67] of gender, age, height, weight [68,69], bone age, cause of death and perimortem pathological conditions [70], the perimortem trauma with differentiation between lesions which occurred because of combustion and those from other trauma [71], the biological resistance of skeletal remains useful for identification in the post-mortem period and in natural conditions [72, 73], the taphonomic details regarding the combustion process, such as combustion temperature, minimum and maximum temperatures, initiators, combustion location [74], duration of combustion [75], the examination of wet bones (with soft parts) and dry bones (without soft parts) and the presence of traumatic injuries [76, 77], the structural changes in the bones due to exposure to high temperatures [78] and to shrinkage and fragmentation under the action of temperature [79, 80], the discoloration of burned bones at different temperatures up to calcination [80, 81], the presence of contaminants or initiators [82, 83, 84], the DNA profile [85, 86] and their presentation as evidence in court or prepared for court [87], these are all aspects of the anthropological examination of burned bones; we add to this the diet, the date they switched to a diversified diet (if it is an infant), the place of residence, migrations, the probable date of death, the social group they belong to, facial reconstruction, the personality type; these are also aspects of the modern anthropological examination of burned bones.

Forensic experts and anthropologists must more and more often defend their results, opinions and conclusions in court and to the public. 20-30 years ago forensic anthropology focused mostly on establishing individual and physical elements, such as the species, number of people, sex, age, height, date of death, perimortem organic or traumatic lesion pathology. Today the circumstances of death and its contextual structure, the reconstitution of the victim's person and thus the anthropological recognition of the group they are part of have gained a greater importance in order to explain their death but also to apply means of prevention of similar events.

The identification and the identity of a person are important moments in recovering their individuality. Even if we can find out from the beginning their identity with the methods of molecular genetics, the forensic anthropological approach of reconstructing the circumstances of the person's death and way of life is still mandatory. On the other hand, forensic anthropology allows for the reconstruction of a person's way of life and of the circumstances of their death even without knowing their identity. The approach is not only anthropological in order to provide information about a person, but it is also forensic in order to provide judicial probative support on the circumstances of committing an alleged crime.

Today, forensic anthropology and forensic medicine are by their nature involved in the prevention of terrorism, in a coordinated intervention in mixed national and international multidisciplinary teams that prevent escalation of violence and human rights violations and must be part of public structures that are able to intervene on behalf of the citizen.

In our opinion, anthropological experts must know both aspects specific to forensic anthropology and forensic medicine, and this can be offered by a solid curricular development within the specialization of forensic medicine (as a classic approach) but can also be obtained through different competences and qualifications, either in stages of self-development of the anthropologists experts or via mixed teams. In any competence scenario we acknowledge that mixed teams are always to salute because bring extra competencies and fresh ideas, whether they are made up of archaeologists, dental anthropologists, physicists, etc.

Any detail which, if known, can lead from a criminological and victimological point of view [88] to the prevention of a new crime is useful for both the justice system and the society; as a result, these cases must be viewed not only statically, but also dynamically in their procedural development.

Forensic anthropology emerges from the ground centered on skull examinations which were told to give answers to all questions [89]. Identification was the paramount task in front of any anthropologist. Then the skeleton came into interest of the forensic anthropologist as the inflicted trauma lesions examination and taphonomy develops [90,91]. We may conclude that today another paradigmatic change has moved anthropology with its tasks and methods from individual identification to person identification and this is to recover not just an identity but a human life, a person and circumstances of his/her death [90,91].

Conflict of interest

The authors declare that they have no conflict of interest.

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