Chapter 15

Personal Identification of Cadavers and Human Remains

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Summary

Personal identification is a field where pathology, anthropology, odontology, and even genetics must merge. Specific features and descriptors (such as scars, moles, gross anomalies) may be sufficient for identification. However, in more complex cases, four main disciplines are involved in the identification of human remains: DNA, fingerprint analysis, odontology, and anthropology (or better yet, osteology). Genetic and fingerprinting methods give a quantitative result, or at least statistics have been performed on the specific traits studied, which allow one to answer in a quantitative manner on the probability of two individuals having similar characteristics—in the first case, for the distribution of different alleles within a population, and in the second, for the frequency of minutiae on the finger. Forensic anthropology and odontology methods, which compare the status and shape of teeth and bones, are valid alternative methods. Methods include comparison of dental work, bone, and tooth morphology, in particular frontal sinus patterns, and craniofacial superimposition. They are advantageous methods because faster and less costly; however, they may suffer, in the view of some judges, from the qualitative and nonquantitative responses they give.

Personal identification must always be carried out with a set of data, after having carefully evaluated the limits and the possible sources of error of each method.

Key Words: Identification; DNA; fingerprinting; odontology; anthropology.

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1. Introduction

An unidentified body comes in many different forms, ranging from a well-preserved corpse to skeletal or badly burned human remains. This is one of the reasons why the process of personal identification is another area where pathology, anthropology, odontology, and even genetics must merge. The previous chapters have focused on the most important steps in achieving a biological profile, i.e., aging, sexing, determining stature, and ancestry, recording every single detail of the remains that may provide a thorough "identikit" of the person, from scars or tattoos visible on bodies with soft tissue residues (one should never forget to always clean the skin of charred or putrefied remains thoroughly so as to not miss any similar details) to bone pathology and dental restorations. This procedure can be completed with facial reconstruction from the cranium in cases of badly decomposed remains. In this way, such a complete identikit can be provided to investigating authorities and the media (newspapers and television) in order to try to achieve a possibility of identification in the case that somebody recognizes the biological profile. In the better-organized countries, this kind of information can be inserted into a postmortem database, which will then be crossmatched with an antemortem database containing data from missing persons in order to reach a prospect of identity or at least possible matches for those specific human remains. At times, circumstantial evidence can help, in the sense that the remains have already arrived at the pathologist's attention with a supposed identity (for example, a burned body in a car whose owner is known).

The previous chapters have all dealt with the steps involved in creating such a profile and reaching a possible identity. The present chapter aims to give general guidelines for everything that happens after that, i.e., definitive personal identification. Whatever the case may be, the forensic anthropologist, pathologist, or odontologist is faced with the necessity of comparing antemortem with postmortem data in order to finalize the identification process.

Identification of a body, even if it is well preserved, is not an easy procedure, and it is necessary for the operator to have a good knowledge of all available methods that can be applied to that particular case. In most countries, before autopsy of a normal identified body, a formal identification of the victim is performed by relatives or friends who officially are considered "responsible" for this identification on a *bona fide* basis. However, in all cases of badly preserved remains or in cases of well-preserved cadavers for which no one can perform a reliable visual identification, biological identification must be performed. Visual identification of well-preserved cadavers carried out by acquain-

tances in some countries is the only adopted and accepted criterion. However, many times this procedure has proven unreliable. Even in well-preserved cases, it is advisable to carry out identification with a combination of criteria and not to depend only on visual identification. In particular circumstances, in fact, this could be invalidated by the emotional condition of the relatives or acquaintances, or by slight postmortem alterations. Thus, particularly in cases of human remains that cannot be visually identified because they have been altered by putrefactive processes, fire, or dismemberment, magistrates must be advised against performing visual identification or identification by means of personal belongings or documents (e.g., identity card, driver's license). The magistrate's awareness of this problem must be seriously stimulated.

How is positive biological identification achieved? Interpol identification guidelines state that an accurate identification can be obtained by comparing ante- and postmortem data, both circumstantial (clothes, personal belongings, and so on), along with the findings from the external examination of the corpse (physiognomic traits, fingerprints, and so forth) and by means of postmortem examination (clinical, dental, DNA data). It is the authors' opinion that even circumstantial information may be dangerous on its own. It may happen that, both by error or intentionally, the personal belongings of a person are found on the remains of another person. Thus, they must be considered as circumstantial indications of identity, but not definite proof. It is clear that the risk posed by each case must always be carefully evaluated.

Within this perspective, one should consider physical biological evidence as the foundation of identification. For this reason, any form on which such data (the so-called descriptors) is collected must be extremely detailed. This implies drawing up, at the external examination, an accurate description both of clothing/personal belongings and body data: sex, height, constitution, skin color, and the like. Some of these features, which are general and observer-dependent, are potentially misleading. However, there are more specific features and descriptors (such as scars, moles, gross anomalies) that often may be sufficient for identification. Finally, within the context of the autopsy, it is possible to carry out a dental examination, to verify organ anomalies, and to take blood samples and samples of other tissues for genetic examination, together with samples and radiographs of bone tissue.

Apart from the issue of identifying a well-preserved cadaver with personal descriptors such as physionomy, tattoos, and so on, there are four main disciplines involved in the identification of human remains: DNA, fingerprint analysis, odontology, and anthropology (or better yet, osteology).

Genetic and dactyloscopic (fingerprinting) investigations are better known to criminal investigation departments and to the magistrates. In the first case, one compares the genetic asset of the remains with those of the presumed relatives (children, parents, siblings) or with that obtained from residual cells on the personal belongings used by the person in life (for example, razors, combs, toothbrushes, and so forth). The genetic investigation techniques are certainly very effective and have great potential. However, at times they may not be applicable as there could be problems in the extraction of DNA from skeletal remains, or relatives suitable for a genetic comparison may not be available—this is often the case of non-European immigrants. On the other hand, concerning the use of dactyloscopic methods, the problem consists sometimes in the fact that the fingerprint is poorly detectable (even if this problem can be partly overcome with techniques to be discussed further on), and that the person's fingerprints need to have been taken in life. This frequently means that he or she has to have a criminal record, is part of the military, or the country of origin registers fingerprints on identity cards. Many European countries have a database (automated fingerprint identification system, or AFIS) that permits one to compare the fingerprints inserted in a databank with those of subjects already fingerprinted in life. Once the fingerprint of the cadaver is entered, this computerized system will return a series of possible matches, which the fingerprint expert will then evaluate.

Forensic anthropology and odontology methods, which compare the status and shape of teeth and bones, are valid alternative methods. They are advantageous methods because they are faster and less costly; however, they may suffer, in the view of some judges, of the qualitative and nonquantitative responses they give. Genetic and fingerprinting methods give a quantitative result, or at least statistics have been performed on the specific traits studied that allow one to answer in a quantitative manner on the probability of two individuals having similar characteristics—in the first case, for the distribution of different alleles within a population; in the second, for the frequency of minutiae on the finger. In the case of morphological methods (such as the odontological and anthropological ones), a unanimous and clear agreement on the quality and quantity of the characters necessary in order to achieve personal identification does not exist. The recurrence of discordant characters settles the case by excluding the identity; some or many concordant characters, particularly if not uncommon within the population, can only permit expression of a judgment of compatibility or possibility; few characters or a combination of characters, rare among the population, will allow one to express a judgment of high probability or certainty.

The authors' experience in Milan from 1995 to 2003 shows that of 312 cases of remains requiring identification, only 218 have been identified. Of these, 81 were badly preserved and required biological methods of identification. The disciplines that resulted in being more useful in identification were, in decreasing order, odontology, dactyloscopy, anthropology, and DNA. Thus, although one must not underestimate the potential of biomolecular techniques, in the past years, because of the high number of immigrants from northern Africa and the East, anthropological and odontological methods have resulted in being increasingly useful.

It is not the purpose of this chapter to deal with the genetic aspects of identification, which are of a more specialized and technical nature. Suffice it to say that adequate sampling from the human remains must be performed (usually blood [if fresh], muscle, bone) and stored at –20°C, at a minimum.

Positive identification possibilities by means of dactyloscopic, odontological, and anthropological methods will be discussed.

2. *Dactyloscopy*

Identification by fingerprint analysis is not a task for the forensic pathologist or anthropologist; qualified police personnel exist for this purpose. However, the biomedical expert dealing with the remains should be aware of the potential for a fingerprint even in badly decomposed human remains. In some countries, it is, in fact, the pathologist or anthropologist who tries to enhance fingerprints on the cadaver, or at least guides investigating authorities in doing so. Thus, the following paragraphs provide guidelines for the treatment of decomposed fingers.

Dactyloscopy carried out on a well-preserved corpse is easy and fast to apply, and for these reasons is the primary approach to identification. Once fingerprints are taken, if the person has a criminal record, the automated fingerprint identification system will find the appropriate identity in a few hours.

The problem arises when the fingertips are compromised by putrefactive and/or decomposition processes (mummification, corification, saponification) or by postmortem factors (such as fire), in such a way that immediate fingerprinting is impossible. Depending on the case, the papillary crests can present deformations consisting of folds of the epidermal or dermal layer (as in mummification), or can be flattened/thinned because of erosive effects of environmental phenomena, or dehydrated, and therefore retracted and fragile, as in the case of exposure to high temperatures and flames. In these cases, specific methods should be used in order to enhance the papillary design.

Very different techniques have been developed to recover the papillary design *(1)*. Chemical–physical techniques (methanol solutions, sodium hydroxide, ethylenediaminetetraacetic acid) are applied to soften and rehydrate the skin, and as a result, extend the fingertip and allow the inking of the papillary crests. Once the finger is softened, subcutaneous injections of glycerin or saline solution can be performed to reinflate the finger. Good results have been obtained also by putting the finger in a saturated saline solution with the addition of sulfuric acid. In spite of the validity of these chemical and physical techniques, they are potentially destructive, complex, and require constant monitoring, solution preparation, pH control, or amputation of the fingers.

In the postmortem transformation context, it is possible to recognize two distinct situations, one characterized by conditions of humidity (as for putrefaction and saponification), the other by shortage of water or dehydration (as for carbonization and mummification). This distinction is necessary because in the former case, the treatment has to be carried out quickly in order to stop the putrefactive processes, whereas for the latter case, this aspect will be less important.

2.1. Mummification

Mummification implies the loss of liquid from tissues. The fingertips thus show more or less pronounced folding that prevents the application of the normal techniques of fingerprinting. A technique frequently used in these cases consists in softening and reinflating the finger. This is obtained by carrying out alternated incubation in 90% methyl alcohol and 5% sodium hydroxide solutions. The immersion times vary from minutes to hours, depending on the cases. However, the sodium hydroxide treatment is destructive for the skin, and it is not advisable to repeat it. Once the fingertip is softened, it is possible to reinflate it by means of saline injections. When the folds have flattened and the papillary design becomes sufficiently readable, it is important to try to ink it or, if it is impossible, to take a photograph with tangential lighting.

Alternatively, a simple method that gives more satisfying results in a very short time has been devised. The method consists in spreading a thin layer of latex on the fingertip (Fig. 1). This latex film, once hardened, can be gently removed from the finger, set on a frame, and inked.

2.2. Carbonization

This implies dehydration, soiling by soot, loss of superficial skin layers, and thinning of the papillary crests. Even with bodies heavily damaged by the

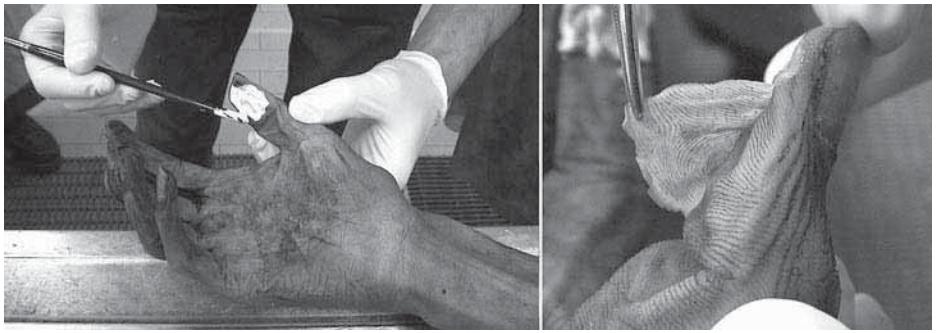

Fig. 1. Spreading a film of latex on mummified fingers, with subsequent removal of the latex film.

combustion process, it is possible to recover fingerprints because, on account of the heat, the fists tend to be clenched, thus preserving the fingertips. In these cases, it is necessary to remove the fingers in order to clean them and work on them. Cleaning is carried out by degreasing the finger with ether and by removing the layer of soot on the fingertip with a soft brush. It is possible to use the technique of rehydration and of reinflation described for the mummified fingers, but the latex method is by far the most effective.

2.3. Putrefaction

Putrefaction leads to peeling off of the skin with a consequent progressive loss of the papillary design. The first step in this case is to block the putrefactive process by hardening the skin via immersion in ethanol for a time ranging from a few minutes to 1–2 h. Dehydration because of the immersion in alcohol, although necessary, introduces serious problems, such as the thinning of the papillary crests, which are already compromised. At this point, it should be sufficient, once the epidermal glove (i.e., the peeled-off skin) has been worn by the examiner, to ink the fingertip and transfer the fingerprint on paper.

2.4. Saponification

Saponified fingers (left in water) present skin flaking, flattening of the papillary crests, and, at times, hardening of the whole finger. The technique recommended in this case is still that of reinflating and inking.

It is clear that sometimes it is necessary to combine these methods, depending on the different and mixed preservation conditions. Finally, it is convenient for the operator (pathologist or anthropologist) to be in close con-

tact with the fingerprint expert who will carry out the identification, to explain what he or she is looking at. For example, the fingerprint obtained from the latex film has to be inverted in "place and colored" before fingerprint comparative analysis.

3. Odontological Identification

Teeth are extremely resistant to decomposition, environmental factors and, to a certain extent, fire. They are therefore of crucial importance for identification, particularly in cases where soft tissues have been altered for various reasons. In addition, teeth, because of all their possible variations in shape, size, and position, constitute a three-dimensional apparatus that is characteristic of each individual. Genes, nutrition, environment, pathology, and dental treatment act synergistically in decreasing the possibility that two sets of teeth may be identical, and thus allow one to express a statement of identity of an unknown corpse.

Odontological identification is based on the comparison between postmortem evaluation and antemortem data concerning the dental status.

Characters such as malformations, anomalies, pathological and traumatic alterations, and therapeutic peculiarities (avulsions, fillings, root canals, caps, dentures) are by many authors considered among the most important factors for personal identification *(2–4)*. However, morphology is also important. One has to consider the fact that improving oral health conditions decreases the need for dental work, particularly in young individuals, and thus leads to the need for identification methods based on simple morphological traits.

3.1. Postmortem Odontological Assessment and Data Collection

In the greatest number of cases, odontological identification is carried out on corpses that have been deeply traumatized, burned, decomposed, or skeletonized. These conditions make the dental arch particularly fragile and impose on whoever is handling the corpse the need for the utmost attention. Before moving the body from the scene of crime, it is advisable to proceed to an initial dental analysis and photographic survey. It is also appropriate to inspect the environment where the remains were found, because dental elements or prosthetic devices may have been moved by larvae or small animals after decomposition. Above all, in the case of highly decomposed cadavers (when the periodontal ligament cannot anchor the tooth to the socket) or burned remains, it is necessary to preserve the teeth so that precious information is not lost during transportation to the morgue. For this purpose, a fixative spray

can be used on the teeth and dental arches, which may be further protected with soft material (gauze) kept in place by a surgical mask.

Before proceeding to the dental examination, a series of photographs of the dental arches, both in occlusion (frontally and laterally) and of the occlusal surfaces (superior and inferior), should be taken, using labial retractors and mirrors for intraoral photography. In the case of a mass disaster, the preparation of a photographic file, possibly in a digital format, greatly facilitates the identification phases and often avoids a second dental inspection.

Although the odontological examination is normally carried out after the autopsy and is therefore facilitated by the removal of the tongue and of the larynx, access to the oral cavity of the corpse is not always easy. When faced with fairly well-preserved bodies, rigor mortis often prevents sufficient opening of the mouth; in these cases, it is possible to practice an intraoral incision of the chewing muscles or overcome the rigor by using levers or a special mouth-opening device, taking care not to damage the dental elements (obviously an alternative could be waiting for the resolution of rigor mortis).

In cases of severely traumatized bodies, decomposed, or charred remains, disarticulation or the resection of the lower jaw may be necessary: after having exposed the osseous surface of the lower jaw, a cut is practiced with a Stryker saw on the ascending branch of the mandible (paying attention not to damage the third molars). If necessary, even the superior maxilla can be removed with a Stryker saw and by working a parallel section to the occlusion level, sufficiently cranial not to damage the dental apex. In case it is necessary to remove the mandible and maxilla from a well-preserved body, one may proceed to an accurate dissection (flap) of the soft tissues from the facial skeleton. The parts removed can be substituted by adequately modeled artificial volumes in such a way so as to provide support to the soft tissues; alternatively, the maxilla and mandible can be repositioned after odontological analysis.

After having accurately cleaned the dental elements, using a probe and a dental mirror, one should proceed to the examination of the dental arches, taking note of any anatomical, pathological, and therapeutic characteristics, and in particular:

1. Presence/absence of each dental element, specifying if it is missing, if the loss occurred antemortem (recent or remote) or postmortem.
2. Periodontal status, presence of calculus, pigmentations, abrasions.
3. Anomalies of shape, number, position.
4. Occlusion.
5. Position, morphology, technique, material and conservation state of each filling.
6. Accurate description of fixed and removable prostheses and osteointegrated implants.
7. Orthodontic treatments.

When possible, the prosthetic devices have to be removed in order to be able to observe the characteristics both of the prosthesis and of the dental elements to which it is anchored. The use of a UV light points out aesthetic restorations otherwise difficult to see.

When the dental arches are not removed *in toto*, it is advisable to make a cast, using materials commonly adopted in dentistry (alginates and silicones). The hardening time for these materials will be greater because of the lower temperature of the oral cavity in a dead body.

Radiographic surveys must be carried out with equipment and material commonly used in odontology and, when possible, they should be restricted to the search for the peculiarities observed in the antemortem comparison materials, such as the presence of endodontic therapy, osteointegrated implants, morphological, and radicular peculiarities of the osseous trabecula and of the pulp chambers. All data collected are then summarized on an appropriate form (Interpol, FBI, Computer-Assisted Postmortem Identification System) that will serve afterwards to facilitate the comparison with the antemortem information.

In Europe, the most frequently used charts are the ones pertaining to the Interpol forms (yellow for collecting data of missing persons, pink to collect corpses' data), which are subdivided in various sections (http://www.interpol.int/Public/DisasterVictim/Forms/Default.asp). Those related to the odontological identification are sections F1 and F2. In section F1 of the pink section, a number and an identification mark is inserted, related to the body, sex (when it is possible to determine it), and various information related to the state of the human remains, to the place and to the circumstances of their finding. In section F2, the dental survey related to the corpse is reported. In the designated squares, all treatments and other particularities can be found. It is important to fill in such forms in a clear manner, using odontological terminology to avoid misinterpretations. In the odontogram, the morphology of each dental restoration is drawn using black for fillings with amalgam, red for gold, and green for aesthetic material. Existing prostheses are always drawn. With regard to missing teeth, it must be specified if the loss is postmortem or antemortem. All the radiographic exams carried out must be indicated with reference to the tooth that is being observed. Finally, an estimation of age, specifying the methods used, is carried out.

3.2. Antemortem Data Collection

The antemortem information, at best, will come from the odontologist who treated the presumed victim in life, who may provide a case history, orthopantomographs, intraoral photographs, and casts. However, even a simple esti-

mate concerning the treatment carried out or an interview with the dentist of the presumed victim could be of fundamental importance in the identification phases. With regard to dental casts, in addition to precious information concerning dental morphology and therapeutic particularities, they also provide information on palatal rugae, which, in view of their interpersonal variability and morphological stability with time, could be utilized for identification purposes.

In the cases in which clinical odontological material is not available, useful information could be obtained from skull radiographs and from photographs of the person smiling (in other words, exposing the teeth). Obviously, because this is not material from a dental clinic, various difficulties in singling out the dental peculiarities useful for identification will be encountered; in a radiograph of the skull in a laterolateral projection, for example, the dental elements are all visible, but the right hemiarches are superimposed to the left ones. In spite of this, precious information on avulsions, root canals, prostheses, and fillings are, however, readable and can be located.

All antemortem data are then summarized in the antemortem identification form that differs very little from the postmortem one for a subsequent comparison. The antemortem form may arrive already filled in by another odontologist, particularly in the case of mass disasters involving subjects of several nationalities; the sources used for filling in the form should always be available for verifying correctness of data. In filling out the antemortem form, each observation (e.g., filling, avulsion) should refer the source and the date on which the source was created. The dental apparatus, mainly for pathological reasons and for medical interventions, is in fact in constant evolution; therefore, the increase of the time interval between antemortem and postmortem data often increases the probability that such characteristics have changed. The in-depth knowledge of the possible evolution of various dental pathologies and of odontological therapy is thus indispensable for a correct interpretation of antemortem and postmortem data. In addition, it has to be taken into consideration that dental nomenclature varies not only among different odontologists, but also among different countries.

3.3. Personal Identification: Comparison of Antemortem and Postmortem Odontological Data: Dental Charts

The antemortem and postmortem forms are then placed side by side and, tooth after tooth, consistencies and inconsistencies are analyzed.

In case there is only one anatomical, pathological, or therapeutic inconsistency among the forms (for example, the presence of a dental element in the postmortem card not reported in the antemortem one, or a therapeutic particularity incompatible with the natural history of the dental element), a

judgment of exclusion is expressed. In cases where the antemortem or postmortem information is lacking or insufficient in number, the comparison among forms leads to a judgment of possibility or compatibility. Further investigations are then necessary in order to arrive at a positive identification. Finally, the simple comparison of forms in cases where the pathological and therapeutic peculiarities are numerous leads to positive identification.

3.4. Personal Identification: Comparison of Antemortem and Postmortem Odontological Data: X-Rays

When the comparison among forms is not sufficient to establish a definite identification, the antemortem and postmortem radiographs can be compared. In the case that the postmortem radiographs are taken with the same spatial orientation of the antemortem ones, a superimposition of the images can help in a positive identification. In comparing two radiographic images, the smallest anatomical, pathological, and therapeutic characteristics must be looked for; even one periapical image rich in peculiarities can lead to a definite identification (Fig. 2).

3.5. Dental Superimposition

Unfortunately, it is not always possible to recover suitable antemortem odontological documentation, both for the lack of regulations obliging the odontologist to register and keep dental charts of patients and in the cases when the suspected victim may have never been to a dentist (a increasingly frequent circumstance, considering the increment of legal and illegal immigrants). On these occasions, photographs of the face of the suspected victims, particularly when the dental elements are clearly visible, are of great importance. Such photographs, supplied by relatives and acquaintances of the missing person, can be used for an identification study based on computer-assisted superimposition between the person's face and the skull of the corpse to be identified or, better yet, when possible, between the dental elements visible in the photograph and a dental cast of the corpse. Craniofacial superimposition is based on the controversial correspondence between soft tissues and a skeletal structure; however, a comparison among dental elements can overcome this problem, because these are the only "skeletal" elements visible during the life of a person. The identification procedure of the dental superimposition can be summarized as follows.

After having selected among the pictures of the missing person those presenting a better visualization of the oral zone, one proceeds to analyze the spatial orientation of the dental arch of the subject in such a way so as to be able to

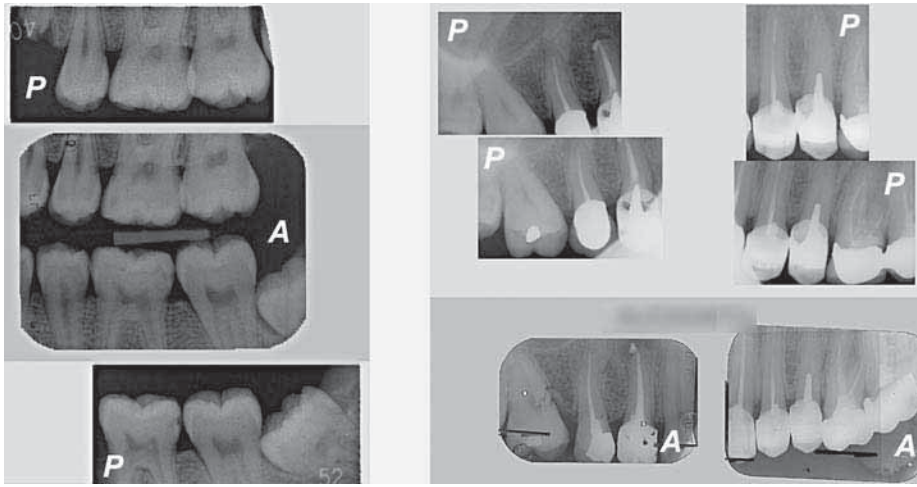

Fig. 2. Identification by means of intraoral radiographs (A refers to antemortem images; P to postmortem ones). To the left, in the absence of therapy, the morphological characteristics of the single dental elements (crowns, roots, pulpar chambers) and their reciprocal positions (third left inferior partially included and mesioinclined); notice also the lesion from caries on the distal surface of the first inferior molar. To the right one can notice the similarities of root canal and dental restorations between A and P.

photograph the cast of the teeth of the remains in the same position. The picture of the cast is then superimposed to the antemortem photograph (photo retouching software allows one to enhance more clearly the areas of major interest during the overlap). It is at this moment that it is possible to study the trend of the superimposition of the profile of each tooth and to express a judgment on the correspondence of the dental profiles examined (Fig. 3).

Discrepancies, if not caused by morphological modifications because of pathological, traumatic phenomena, or dental work, will lead to an exclusion.

4. Anthropological and Osteological Identification

In order to identify a person, it is also possible to compare the shape of bones *(5–19)*, just as though each bone were a fingerprint, even if, as has been mentioned, these methods are not standardized. It is clear that the comparison, as always, must be carried out between antemortem and postmortem radiographs of different skeletal districts. Thus, if radiographs of the various osseous

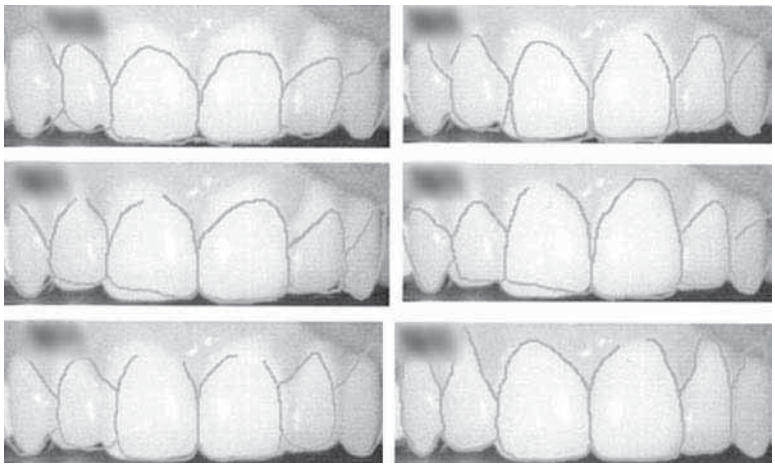

Fig. 3. Some examples of dental superimposition. In the background, one can note the antemortem dentition to which the black profile of the postmortem cast is superimposed. The only matching superimposition is on the bottom right.

districts (for example, head, thorax, limbs, abdomen, and the like) are available, it will be possible to compare the morphology of the skeletal elements visible in the radiograph, with the same osseous elements belonging to the human remains (both working on the actual osseous elements, and on their radiographs).

Apart from exceptional morphological peculiarities (osteophytes, bone calluses, and so on), the difficulty consists in determining which and how many are the morphological elements sufficient for a definite identification. The literature states that personal identification in this way is carried out by means of a meticulous comparison of details. However, a minimum number of points do not exist—as they exist instead for fingerprints—in order to carry out an identification. Usually, it is intended that one to four characters, without evident discrepancies, are considered sufficient for identification. The problem is that an agreement does not exist yet on what exactly is meant by a "significant" character. It is clear that the areas compared must be scarcely modifiable in time. However, the peculiarity of the character and the consistency between the antemortem and postmortem shape is left, in part, to a subjective evaluation and to the experience of the operator.

The most hailed districts in the literature are the frontal sinus and the vertebrae. For the comparison of frontal sinuses, there are even algorithms

that allow one to achieve a judgment of identity; the shape of frontal sinuses is so peculiar that it is even different in homozygous twins (like fingerprints). For the other districts, such precise indications do not exist.

4.1. Superimposition of the Frontal Sinuses

As previously mentioned, for this particular skeletal district there are several algorithms *(5,6)*. Particularly famous is that of Yoshino et al. *(6)*. An antemortem radiograph is used where the frontal sinuses are clearly visible. A postmortem radiograph is then carried out on the skull or head, which is oriented in a similar position to the antemortem picture by means of progressive approximations, aimed at obtaining identical ratios between lines drawn on a transverse and coronal plane, between craniometric points. Briefly, on the radiograph, it is possible to draw two lines parallel to the median sagittal plane running between alveolare and nasion. Subsequently, on the transversal plane, a line is traced tangent to the occlusal border of the central superior incisors and another line going through the most cranial point of the edge of the orbits. The ratios between these distances are then calculated. The skull is radiographed in different positions, similar to those of the antemortem plate, until a positioning is found that gives ratios that can be superimposed to those of the antemortem radiological picture.

It is then possible to proceed with different classification systems in addition to evaluating the natural morphological concordance or discordance of sinus morphology. The Yoshino method is based on the attribution of specific scores for each of the following parameters: asymmetry index (ratio between the area of the smaller frontal sinus A1 and the larger one A2, calculated with a special software); left sinus larger than the right sinus or vice versa; trend of the profile of the superior edge of the left and of the right sinus; presence of the number of arches per septum; presence and location of partial septa; presence and location of supraorbital cells; and so on. To all these traits a score is given. This is a classical example of a method trying to quantify the morphological closeness of osteological traits. However, once the cranium has been properly oriented and radiographed, a qualitative comparison of sinus morphology may be sufficient (Fig. 4).

4.2. Comparison and Superimposition of Other Skeletal Districts

As previously stated, it is possible to compare the forms of other osseous districts *(7–19)*. Among the most utilized are the vertebrae. Of these, the transverse processes and the spinal process, which present very different shapes from one another, are particularly useful. However, there are no algorithms

Fig. 4. To the left, the postmortem radiograph of skeletal remains, to the right the antemortem radiograph of the subject to whom it was assumed the skeleton belonged. The margins and shape of the frontal sinuses, identical in both pictures, can be recognized.

yet that allow a quantitative or semiquantitative estimate of the comparison. The answer is left to the morphological evaluation of the observer. It is evident that it is necessary to carry out the comparison of two structures oriented in the same manner; therefore, an orientation of the postmortem material must be found so that it best approaches the antemortem radiograph.

4.3. Craniofacial Superimposition

A "last-chance" possibility should be craniofacial superimposition. It consists of the superimposition of a photograph of the skull with a photograph, similarly oriented, of the face of the living person. The correspondence between two subjects is evaluated based on the correspondence of several anatomical landmarks that can be found on the skull and on the face. As can be easily understood, this superimposition has far less credibility than dental superimposition. In dental superimposition the same elements—teeth antemortem and teeth postmortem—are superimposed; in craniofacial superimposition, the soft tissues are compared with the skeleton. For the sake of completeness, Fig. 5 illustrates a general example that summarizes most proposed methods and whose aim is to demonstrate the difficulty in matching specific landmarks.

The supporters of this method report a reliability of 96% whenever the possibility exists of both frontal and lateral superimposition, but the discrepancy among numerous anthropologists concerning the degree of certitude supplied by this type of investigation is large. In the authors' opinion, this method should never be used alone for identification because there are several problems to overcome in the comparison between a structure with soft tissues (face) and a structure made of hard tissue (skull). It should be used only for excluding identity if gross incompatibilities are present.

5. Conclusions and Guidelines

This chapter concludes with an outline summarizing possible solutions (at present) for performing positive identification of human remains by comparing antemortem and postmortem data, with the relative advantages and disadvantages.

5.1. Well-Preserved Body

Even if the purpose of this chapter is not to deal with the identification of the well-preserved cadaver by means of the comparison of facial physiognomy, it should be stressed that it may be more difficult to compare a dead face with the picture of a living face in the attempt to declare that it is the same person. This is confirmed by the difficulties encountered by anthropologists dealing with the identification of living individuals on photographic material (for example, on video surveillance recordings of bank robberies, and the like). In these cases, it is necessary to compare the physiognomic traits of the person represented on tape or on a photograph with the face of the suspected thief or assailant. Whereas this appears to be a banal and intuitively simple activity, it is anything but simple. Comparing the morphological and metric traits of two images for arriving at a definite identification of the subject is still complex; this is because of differences in orientation of the two images and of the lack of standardization of such procedures. In the same manner, in the case of a well-preserved cadaver to be compared with a photograph of a living person, serious problems in determining the traits that may be crucial for identification can turn up. It is for this reason that it is important to support a mere resemblance with specific descriptors such as scars, tattoos, moles, and so forth.

5.2. Putrefied, Burned, Partly or Completely Skeletonized Human Remains

For this type of material, depending on which districts are better preserved, the following methods should be applied.

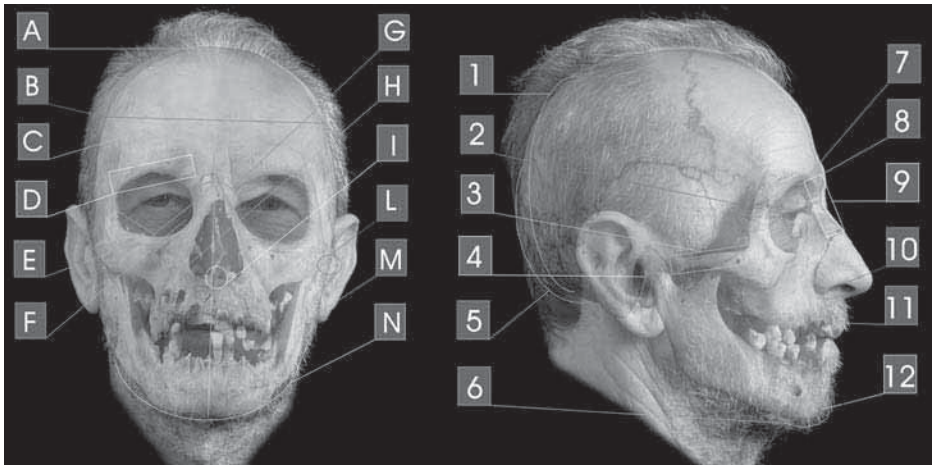

Fig. 5. Craniofacial superimposition. After having selected images of the missing person, proper spatial orientation of the skull and enlargement of the picture (trial and error) are achieved. Then superimpositions are usually performed in the frontal and lateral views. The figure shows an example of craniofacial superimposition in the frontal and lateral position. The letters (frontal) and the numbers (lateral) indicate the landmark for which the correspondence between face and skull is evaluated. At the points where the graphic indication is absent, the corresponding landmarks are not detectable. The observed criteria for the comparison in norma frontalis, marked with letters A to N are the following: A, the length of the skull from bregma to mention must be included in the face—the bregma is generally covered with hair; B, the width of the skull must match the forehead area: C, the temporal line, if visible on the face, should correspond to the temporal cranial line; D, the eyebrows generally follow the superior edge of the orbit to the medial and central third—they continue superiorly to the lateral third, whereas the edge of the orbit deviates inferiorly; E, the orbits contain the eye entirely; F, the lachrymal groove, if distinguishable on the photograph, lines up with the osseous groove; G, the width of the nasal bridge must correspond in the two images; H, the width of the nasal aperture falls within the external margins of the nose; I, the nasal spine is situated above the inferior edge of the medial nasal crus; L, the external auditory meatus is medial to the tragus—this can be adequately evaluated by a marker inserted in the ear; M, the oblique line of the mandible, if visible on the face, corresponds to the same line on the skull; and N, the mandibular curve is similar to the curve visible on the face. In norma lateralis: 1. The skullcap must coincide with the height of the head. 2. Sometimes it is possible to notice the margin of the frontal process of the zygomatic bone that should match the one on the cranium. 3. The margin of the zygomatic arch of the skull is also superimposable to that of the face. 4. The porion is slightly behind the tragus and below the

5.2.1. Significant Descriptors

This is the case of putrefied bodies presenting countermarks (or features) so singular that they may be used for identification purposes. Examples of these identification instruments are residues of tattoos, scars, bone prostheses or anomalies, unusual mutilations, or surgical operations.

5.2.2. Dactyloscopy

It is always worthwhile trying to restore the papillary crests in order to be able to obtain sufficient dactyloscopic data for the comparison of fingerprints. This, however, presumes that the subject's prints were taken during lifetime and that antemortem fingerprints of the subject are available.

5.2.3. Odontology

If a detailed antemortem dental chart, dental radiographs, or other clinical dental data exist, they can be used for comparison with the dentition of the human remains. Such data, however, must be available and the dentition of the remains fairly well preserved. The advantages of this method are its rapidity and low costs. One disadvantage, compared to DNA analysis, could be the inability to quantify the result. For example, it is almost impossible to provide a judge with the numerical probability that two different individuals may share the same dentition. Many odontologists, however, feel that quantification of the result would be useless and that morphological methods are based on the operator's experience and common sense *(4)*.

5.2.4. DNA

This is the most popular method, and the most expensive. It is necessary, nevertheless, to be able to extract the DNA from the remains, and in the case of dry bone, this can be difficult for the presence of PCR inhibitors and

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helix crus. 5. The occipital curve is placed inside the margin of the nape. 6. The anterior protuberance of the mandible is behind the chin. The chin form corresponds to the mandible form. 7. The lateral margin of the eye is situated within the orbit. 8. The profile of the glabella both of the skull and of the face must be similar. 9. The glabella, the nasal bridge, and the region of the nasal bones are the most significant. The prominence of the glabella and the depth of the nasal bridge follow closely the contour of the thin layer of overlying skin. The nasal bones fall within the margins of the nose. 10. The front nasal spine is situated posteriorly with respect to the base of the nose, close to the more posterior portion of the lateral septum cartilage. 11. The prosthion is posterior to the anterior margin of the superior lip. 12. The pogonion is posterior to the indenting noticeable in the chin where the orbicularis oris crosses the chin muscle.

degradation. Furthermore, there may be no adequate relatives for DNA comparison or objects such as toothbrushes or combs from which to extract the individual's antemortem DNA may not be retrievable (as in the case of vagrants and illegal immigrants). The advantages of this method are being able to supply a quantitative result because of studies on the distribution of the alleles of specific loci within a certain population, which makes it possible to provide the probability that another person shares the same genetic asset. Other possible setbacks may be that it is more expensive and requires more time.

5.2.5. Anthropology–Osteology: Image Superimposition

These methods are applied when the above-described methods are not applicable. Superimposition can be dental or craniofacial. As already mentioned, the dental superimposition requires the existence of a decent-quality photograph of the living subject (smiling) in order to be able to compare the subject's profile with that of the human remains. Craniofacial superimposition, where craniometric points of the soft tissues are compared with craniometric points of the remains, is less reliable. These investigations require good-quality photographs. In the case of dental superimposition, the methodology, although incapable of quantifying the error, at least compares the same structures.

Radiological comparison of frontal sinus shape or the morphological correspondence between the shapes of any bones (e.g., vertebrae) can be a valid method of identification, although one must be very cautious in matching the orientation of the antemortem and postmortem radiographs and in looking for sufficient corresponding traits.

In conclusion, results always need to be carefully examined by an experienced observer. Personal identification has to be carried out with a set of data, after having carefully evaluated the limits and the possible sources of error of each method.

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