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Grado en Odontología

CRANIO-PHOTOGRAPHIC SUPERIMPOSITION WITH DENTAL STRUCTURES

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ABSTRACT:

Introduction: cranio-photographic superimposition with dental structures consists in the overlay of the ante-mortem photograph of the victim with the post-mortem photograph of the retrieved skull through the analysis of determined craniometric and cephalometric landmarks. Its application has led to the exclusion of a suspected person or to the actual positive identification of the cadaver. The difference of its use has been determined by the presence or absence of dental structures. Through the years it has undergone an evolution passing from a static photographic superimposition to a video superimposition to lastly reach the actual computer-assisted superimposition. **Objectives:** the objectives were to describe the importance of cranio-photographic superimposition, to compare it with the presence or not of dental structures and to compare it to the other necro-identification techniques. **Methodology:** thirty-three articles and two books have been examined. The databases used were: PubMed, Medline Complete, Google Scholar and Academic Search Ultimate. The key words used were: cranio-photographic superimposition, craniofacial superimposition, forensic dentistry, identification, skull landmarks, video superimposition and computer-mediated superimposition. **Discussion:** this method has aroused the interest of many authors that gave their opinion rather in a positive or dubious way and compared this procedure with the other methods of identification and focused on the presence of dental structures in the corpse. **Conclusion:** this technique has been used in many situations, mainly when the retrieved body was in critical conditions leading to a positive identification in those cases in which the teeth were present. It has not been always considered as a first choice compared to the other techniques, but it still remains an essential necro-identification method.

RESUMEN:

Introducción: la superposición cráneo-fotográfica con estructuras dentales consiste en la superposición de la fotografía ante-mortem de la víctima con la fotografía post-mortem del cráneo que ha sido recuperado mediante el análisis de determinados puntos craneométricos y cefalométricos. Su aplicación ha llevado a la exclusión de una persona sospechosa o a la identificación positiva real del cadáver. La diferencia de su uso ha sido determinada por la presencia o ausencia de estructuras dentales. A lo largo de los años ha sufrido una evolución pasando de una superposición fotográfica estática a una superposición de vídeo para finalmente llegar a la actual superposición asistida por ordenador. **Objetivos:** los objetivos fueron de describir la importancia de la superposición cráneo-fotográfica, compararla con la presencia o no de estructuras dentales y compararla con las otras técnicas de necro-identificación.

Metodología: se han examinado treinta y tres artículos y dos libros. Las bases de datos utilizadas fueron: PubMed, Medline Complete, Google Scholar y Academic Search Ultimate. Las palabras clave utilizadas fueron: superposición cráneo-fotográfica, superposición craneofacial, odontología forense, identificación, marcas del cráneo, superposición de video y superposición mediada por ordenador. **Discusión:** este método despertó el interés de muchos autores que dieron su opinión de manera más bien positiva o dudosa y compararon este procedimiento con otros métodos de identificación y se centraron en la presencia de estructuras dentales en el cadáver. **Conclusión:** esta técnica ha sido utilizada en muchas situaciones, principalmente cuando el cuerpo recuperado se encontraba en condiciones críticas que condujeron a una identificación positiva en aquellos casos en los que los dientes estaban presentes.

No se ha siempre considerado como una primera opción en comparación con las otras técnicas, pero sigue siendo un método de necro-identificación esencial.

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1. INTRODUCTION

1.1 Importance of forensic odontology in necro-identification

Forensic odontology is a branch of dentistry specialized in personal necro-identification for social and medico-legal purposes. Dentists and forensic odontologists are very relevant when there are criminal cases to solve since many times are called from the court to develop some expertise to prove the identity and recognition of an unknown victim [1].

Forensic sciences study the cadavers in both environmental catastrophes like tsunamis, earthquakes, cyclones and in criminal acts such as murderers, accidents and terroristic attacks. All the before mentioned situations share a common point that is the possibility of generating the death of a person and the subsequent difficulty in recognizing it. [2] There are many methods and techniques used in forensic odontology and anthropology as for example DNA analysis, fingerprints analysis, dental examination and cranio-photographic superimposition with dental structures [3].

Dental examination is a pivotal analysis of forensic odontology since teeth are both unique for every person and one of the most resistant tissues present in a human being. [4] Dental fillings, restorations, prosthesis, root canal treatments, implants and all the dental treatments that can be performed in a dental clinic becomes essential for the study and recognition of the victim [2]. The chemical conformation of dental structures, whose hard tissues are enamel, dentin and cement [2], makes them extremely resistant to heat, atmospheric agents and decomposition, becoming essential in catastrophic disasters [4]. Every part of the teeth can be analyzed under different aspects and reveal important clues. Commonly, forensic odontologists start

by comparing all the antemortem with the postmortem data [2]. Some methods comprehend the analysis of tooth prints, that can be very relevant as seen for example in the criminal case of Ted Bundy [5]. Cheiloscopy and rugoscopy are other important methods of recognition included in forensic odontology as they are methods of individualization [6].

Lastly, x-rays analysis may represent a key record to identify cadavers [2,6]. An example where antemortem x-rays turned out to be decisive is the case where Hitler's teeth were studied postmortem and were compared to his antemortem radiographic data, confirming the correspondence of the analyzed specimens with the identity of the Fuhrer [7]. All the information that can be collected from the family or from the dentist of the victim like the medical history and the odontogram may become crucial for the identification of the corpse [2].

1.2 History of cranio-photographic superimposition

Cranio-photographic superimposition has evolved since its first appearance in the early 20th century, passing from the initial technique of static photographic superimposition in the 1930s to the following technique developed that was the more dynamic video superimposition, born in the 1970s. With time, another technique has been developed thanks to the technologic revolution that our world has faced and is the one that implies the use of computer assistance. The latter has been used for the first time in the 1980s [8,9]. This improvement has been possible thanks to the evolution of both technology and forensic sciences.

The precursor of craniofacial superimposition is Welcker that in 1867 studied the retrieved skull of the famous poet Dante Alighieri [10].

The birth of cranio-photographic superimposition happened in concomitance with facial approximation since both these techniques are related to soft tissues and hard tissues of the head although they have different objectives and methods [9].

Broca with his studies developed in 1875 about the correlation between the soft tissues and cranial structures, Bertillon in 1896 and later Martin and Saller in 1966 gave some important knowledge that were then used as a starting point for cranio-photographic superimposition [3,10].

In 1937, with the Ruxton case developed by Glaister and Brash, cranio-photographic superimposition became more famous and relevant and was taken as an example to solve other later cases. This news story reported the murder of Isabella Ruxton and Mary Rogerson of 1935.

Once the corpses of the two victims were discovered, it was hard to identify to whom the skull belonged because the rests did not allow an immediate recognition. For this

reason, the use of cranio-photographic superimposition was implied to solve the mystery and became a very useful complementary method [10,11].

Image 1: Isabella Ruxton's case [12]

Another famous case reported by Simpson in 1943 regarding the Harry Dobkin affair in which the latter murdered his wife Rachel Dobkin. In this case, in order to achieve the identification of the victim, craniofacial superimposition was taken into account. One of the other cases that took as reference the Ruxton's case were the Baptist Church Cellar Murder, the study provided by Gordon in South Africa and the Plumbago Pit case of 1947.

Only in 1962 Sen documented that this technique has been approved by a court as an actual positive identification method. After this judicial precedent where photographic superimposition was included as a method of identification, many other cases used it as a tool to identify victims [12]. Cranio-photographic superimposition became more and more famed when in 1985 the body of the notorious "Angel of Death", Dr. Josef Mengele's was retrieved in Brazil after a long time of researches. In order to confirm the body's identity also this forensic technique was used. The superimposition was

performed with the use of pictures taken at different ages and both confirmed his identity [9,10,12,13].

In all the listed cases, the method applied was the earliest one to be developed, known as the static photographic superimposition. With time, also the other two techniques were applied to help forensic anthropologists and odontologists in order to recognize cadavers. The video superimposition was originated by Helmer and Grüner and right after its development it has been applied in many different cases [12].

In 2003, craniofacial superimposition was used for the first time as an exclusion method of identification in a mass disaster in the Sonora desert of Arizona. The third generation of craniofacial superimposition that comprehended the use of computer was applied by FBI in 1992 to a found mandible and cranium. Computer-assisted craniofacial superimposition has revealed relevant also in the case of Dr. Eugénio Antonio Berríos Sagredo in 1995. There are many software that can be used to develop this computer-assisted superimposition and one of them is for example Adobe Photoshop [12].

1.3 Craniofacial superimposition

As previously mentioned, one of the methods for person identification is cranio-photographic superimposition with dental structures. This method, due to its low invasiveness and inexpensiveness, is one of the most known and used techniques in forensic medicine for the identification of cadavers [8]. It can be applied as a unique source for positive identification or as an accessory tool to other common identification analytical methods providing enough information to exclude and discard the possibility of the suspected person present in the photograph to correspond to the cranium found [14].

In many situations like major disasters and accidents, the body of a dead person may be found dismembered, in an advanced state of decomposition or it can be retrieved already completely skeletonized [15]. Especially in the latter cases, since the only remnants of the victim are the skull, teeth and bones, skeletal analysis are fundamental in aiding the process of victim's recognition. Of all the techniques available, craniofacial superimposition can play an important role in the recognition of the victim's identity.

This method consists in comparing the antemortem photograph of the presumptive victim with the skull that has been exhumed [16]. Once the forensic anthropologists or odontologists have these two elements, then the next procedure consists in superimposing the picture of the presumptive victim with the retrieved cranium [17].

This study is performed by taking as reference points some key anatomical landmarks, teeth included, present in the cranium of every human being [17].

The hardest part of this technique is to perfectly superpose these elements since photos of the victims may be out of focus or with atypical angulations. The best way to find a positive identification and less percentage of mismatches is to analyze more

than one antemortem picture with the postmortem picture of the skull of the cadaver [16].

Just by looking at the cranium morphology of the dead person, if there are no soft tissues remaining, it is possible to provide some basic but very useful information regarding the victim. One of these would be the sex and the age since the skull and teeth have some typical features proper of the female and proper of the male, like the dimensions. Furthermore, the rests can allow the forensic anthropologist or odontologist to recognize the general geographical location of origin [18]. Cranio-photographic superimposition is considered a method for general identification but when there is also an analysis of the dental structures, it becomes an individualization method for identification.

The skull has many landmarks that are necessary to guide and perform an effective superimposition and these references in the cranium are used for all the three types of craniofacial superimposition. These craniometric points were developed in 1966 with the studies performed by Martin and Saller [19].

The craniometric landmarks are the ones located in the skull, while the cephalometric landmarks are the ones located in the soft tissues of the face [10].

The main craniometric reference points are: [10,12, 19]

1. Porion: reference point identified in the skull at the level of the external auditory meatus of both sides.
2. Dacryon: is the reference point located at the level of the lateral orbital wall, where the nasal, maxillary and frontal bone join.
3. Pogonion: is the anterior reference point located at the level of the center of the mental protuberance.

4. Glabella: the reference point located at the level of the most prominent middle point in between the supraorbital ridges.
5. Frontomalar temporal: is the reference point located at the most lateral level of the union between the zygomatic and frontal bone.
6. Gnathion: is the reference point located between the pogonion and the menton, in the most inferior part of the mandible.
7. Nasion: is the reference point located at the level of the union between nasal and frontal bones.
8. Gonion: is the reference point created with the junction of the tangent of the body of the mandible and the posterior tangent of the ascending ramus of the mandible.
9. Nasospinale: is the reference point located at the level of the union between the midsagittal plane and the tangent of the inferior borders of the nasal apertures.
10. Prosthion: is the reference point located in between the superior incisors' apexes, at the level of the alveolus.
11. Zygion: the reference point located in the most laterally position of the zygomatic arch.

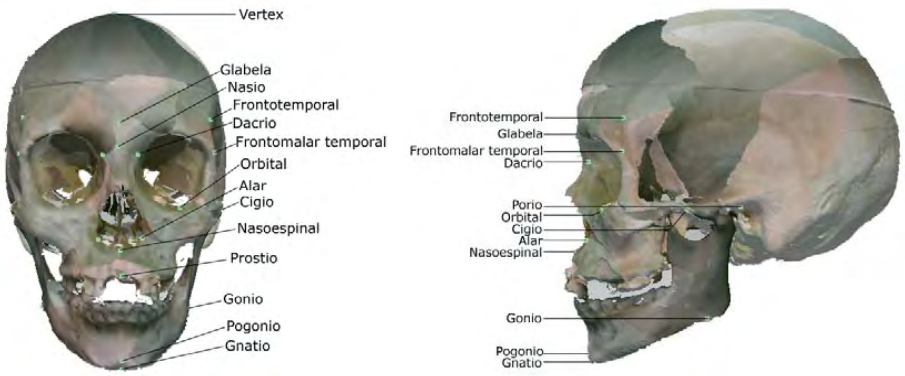

Image 2: Craniometric landmarks from a frontal and lateral view [19]

The main cephalometric reference points are: [10, 12, 19]

1. Endocanthion: the reference point located in the internal part of the eye's commissures
2. Alare: is the reference point located in the most lateral side of the alas of the nose
3. Pogonion: is the anterior reference point located in the center of the chin, at the soft tissues level
4. Prosthion: is the lowest reference point located at the level of the gingiva of superior maxillary incisors
5. Glabella: is the reference point located at the level of the most prominent part in between the eyebrows.
6. Nasion: is the reference point located at the level of the nasofrontal suture, in the root of the nose.
7. Labiale superius: is the reference point located in the middle of the upper vermilion border.
8. Labiale inferius: is the reference point located in the middle of the lower vermilion border.
9. Gonion: is the lateral reference point located in the mandibular region, at the level of the angle.
10. Gnathion: is the reference point of the soft tissues located in the mandibular region comprehended between the pogonion and the menton.
11. Tragion: is the reference point located 1-2 mm inferiorly to the spine of the helix, at the level of the ear, superiorly to the tragus.

12. Zygion: is the lateral reference point located in the most prominent part of the zygomatic arch.
13. Menton: is the reference point located in the most inferior region of the chin.
14. Subnasale: is the reference point located at the level of the union between upper lip and nasal septum, in the middle of the columella.
15. Ectocanthion: is the reference point located medially to the Whitnall's tubercle, at the level of the lateral canthus of the eye's commissure.

Image 3: Cephalometric landmarks from a lateral and frontal view [10]

The identification is then realized thanks to the measurements between both the craniometric and cephalometric reference points even though is not always easy to find the exact points in the picture and in the retrieved skull [19].

1.3.1 Photographic superimposition

Photographic superimposition is the precursor of the now more advanced methods used for necro-identification. This method consists in superimposing a two-dimensional ante-mortem photograph, usually given by the family, of the presumptive victim with the unidentified three-dimensional post-mortem skull retrieved [20].

This technique implies the use of traditional tools such as photographs and x-rays [21]. To perform the most reliable overlay, it is suggested the use of many images of the cranium in order to find the same angulation depicted in the picture [21].

There are three main steps to follow to achieve the most effective photographic superimposition: face enhancement, skull-face overlay and decision making [12].

In the first stage, there is the analysis of the antemortem photographs to create a life-sized image. Some factors influence the success of this stage like the equipment used that comprehends the lenses and the focal length [12].

The enlargement is facilitated by the use of an object that acts like a scale but in many cases, is not easy to find it. In these difficult cases a useful tool can be the measurement of the distance between the pupils of 6 cm in order to obtain an enlarged picture almost to life-size [21,22]. Furthermore, other references may be used to perform the life-size enlargement such as the size of the dentition and the craniometric and cephalometric landmarks. The only limitation that can occur when taking into account the anatomical landmarks is that the points in the cranium are easily recognized and are more or less precise, while the identification of those points in the face of the victim both, before taking the picture or after, results way more difficult and less accurate also because they vary depending on the expression of their face, the age and the weight [22, 23].

There is a problem in this procedure that is not easy to avoid because in the step of enlarging the image, the quality and focus can be altered and be lower than the starting photograph [21].

In the second step, where the actual overlay occurs, there are no common guidelines to follow but every author developed his own method that included the use of craneoforos, picture with transparencies or many other techniques. The cranium landmarks are for sure the most effective and used method to develop the superimposition [12].

The actual time-consuming challenge of this procedure is not only the previously mentioned difficulty of identifying the anthropometrical reference points but most of all is extremely hard to achieve the same orientation of the picture in the skull.[23].

Lastly, it is necessary to pass the last step in which the decisions most of the times are not actually objective, but are subjective as a consequence of the difficulty of this procedure to be accurate and precise [12].

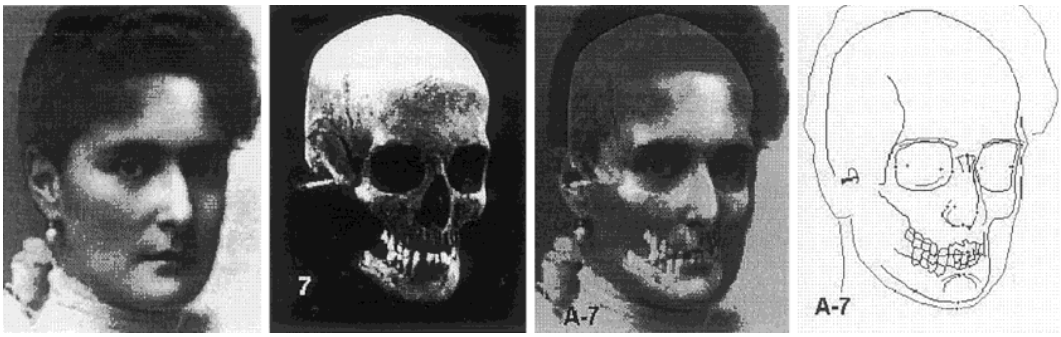

Image 4: Example of photographic superimposition of Alexandra Romanova [17]

1.3.2 Video superimposition

This second method, introduced by Helmer and Gruner, is the video superimposition and it still consists in superimposing the antemortem with the postmortem data acquired but with a different methodology [22]. This technique differs from the first one

since the numerous pictures needed in the traditional photographic superimposition are not needed anymore because with the video, the cranium can be oriented and changed through the video recording [21]. The procedure of video superimposition is a long and time-consuming procedure [24].

This type of superimposition, compared to the classic photographic one, is considered dynamic since it does not use just a still position but it implies the use of moving videos providing a “live image” and this has been possible thanks to the change from a simple photographic camera to a more complex video camera [24, 25]. Also CT scan images can turn out to be useful in this procedure [21].

The video superimposition technique requires the use of specific equipment that consists in: a video mixing device, one to three monitors, two video tubes, a recorder for the cassette of the video and lastly a desktop computer. Iten promoted the use of at least three monitors to perform a more effective skull overlay [24]. The skull of the deceased person is taken with the first tube and seen in the first monitor while the picture of the suspected victim is taken with the second tube and seen in the second monitor [26]. Once taken the two images, is necessary to use the mixing unit that allows to mix the two pictures acquired and some vertical and horizontal sections can be created. The sections and the pictures previously mixed are seen in the third monitor [26].

This technique has many advantages compared to the photographic superimposition since it minimizes the possible limitations that that technique has. The time needed compared to the photographic superimposition is much lower thanks to the possibility of matching the pictures on the monitors [12, 26,27].

Even though it is a more recent technique compared to the static photographic superimposition, some steps will be exactly the same as the enlargement, sizing and the orientation of the skull with the picture. So, also in this method the craniometric and cephalometric landmarks result very useful. The orientation procedure is similar to the photographic superimposition, but in the video one is easier to manipulate the images thanks to the zoom mechanism present in the camera [27].

In the end, what also really matters are the skills and knowledge that the forensic anthropologist has when analyzing and performing any type of superimposition [26].

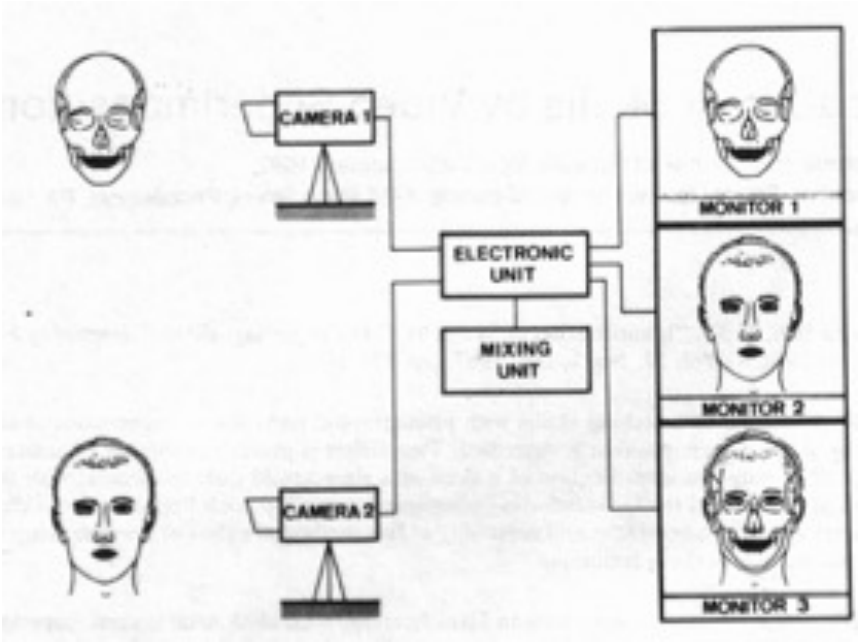

Image 5: Steps of the video superimposition technique [26]

1.3.3 Computer-aided superimposition

The last generation of craniofacial superimposition implies the use of the new technologies that have generated with time. This technique is less time consuming and has a higher degree of efficiency compared to the previous ones [27].

There are many software that can be used to perform this procedure, some of them are: Adobe Photoshop, Corel Draw and Rapid Form [27,28].

The computer is an efficient tool that can be used for the entire procedure, so, for all the steps or just for one of those stages. There are different types of computer-aided superimposition such as the photographic one, the video one and the 3D-2D computer-aided craniofacial superimposition [12].

Furthermore, there is another differentiation that has to be done when referring to computer-aided superimposition and it consists in having the automatic or the non-automatic methods [12,27]. The automatic one implies the use of some equipment whose aim is to reach an identification itself with computer programs. The non-automatic one stores all the visual data and information through the use of digital materials such as a computer. The thing that differentiates this from the automated one is the fact that this one does not have the ability to recreate and make automatic the human activity so the orientation and dimensions are changed by the anthropologists by hand [12].

With the use of these new technologies and software, especially in the automated method, the superimposition becomes easier to assess since the computer does the major part of the superimposition and later the forensic anthropologist has to checks that everything has been performed well like the position, the orientation, the

dimensions and anatomical landmark references both on cranium and on the face of the picture [11].

The computer-aided craniofacial photographic superimposition implies the use of a computer in order to provide the overlay with the use of the antemortem pictures of the suspected victim [27].

The computer-aided craniofacial video superimposition is a mixture between the video one and the application of software and computers to help for example the visualization, sizing and identification of the anatomical landmarks [27].

The computer-aided craniofacial 3D-2D superimposition is the newest one and will be the one that anthropologists will use more in the future because it lowers the separation between the cephalometric landmarks and the craniometric ones [27].

With one of the most used software, the Adobe Photoshop, there is the possibility of performing the overlay by dragging the image and dropping it over the other picture or by copying the photograph and pasting it on the top of the antemortem image. Right after is necessary to adapt and manipulate the two pictures and trying to develop the more accurate superimposition possible [28].

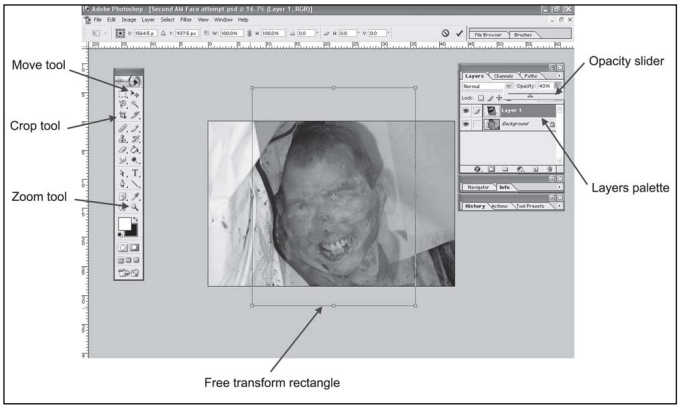

Image 6: Adobe photoshop computer-aided craniofacial superimposition [28]

1.4 Dental superimposition

Dental superimposition is a crucial and determinant method to identify the unidentified cadaver since teeth are individualistic and are unique in every human being. In fact, every time a body is retrieved, one of the first things that the forensic team study are the dental tissues [28,29,30].

In many cases to study the teeth of the victim all the antemortem data are evaluated such as photographs of the suspected person when smiling or where teeth are visible, x-rays or plaster study models and in a second moment these are superimposed with the postmortem pictures of the same structures taken from different angulations. This method is very useful and not considered just as an exclusion method but actually as a tool for providing positive identification [28,30].

There are cases in which the entire skull is retrieved and is intact and other situations in which the only thing that is found are teeth. In this case the process of identification becomes more complex but still possible since teeth can be analyzed in many aspects, by focusing on the periodontal status, on the anatomical characteristics and if are compared with the data of the suspected victim antemortem like radiographies and pictures and are superimposed, there are still many chances of finding an actual match and necro-identification [28].

To perform a dental superimposition there are different steps; first is necessary to photograph the victim, then taking a plaster model of the teeth and again a picture is taken. Subsequently the images collected are opened in a computer with installed one of the previously mentioned software like Adobe Photoshop and the overlay is then executed. Another very useful software is the Facecomp one that permits to the

forensic odontologist to put in contrast geometric images designed by taking into account the anatomical landmarks of the photographs studied before [30].

To carry out the overlay of dental structures all the details of the teeth are analyzed such as the occlusal anatomy with the marginal ridges, the mesial fossa, the pits and fissures and all these particularities are compared with the antemortem data [31].

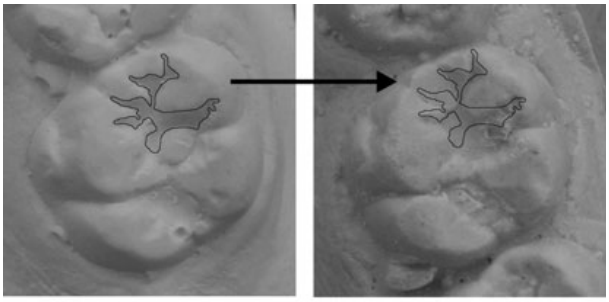

Image 7: Dental superimposition of antemortem and postmortem plaster model [31]

The success of dental superimposition depends on the amount of the antemortem pictures collected, the quality of these pictures that can alter the anatomical characteristics of the teeth, and also the quantity of time that has passed between the antemortem and the postmortem photographs because many things can change through the years [32].

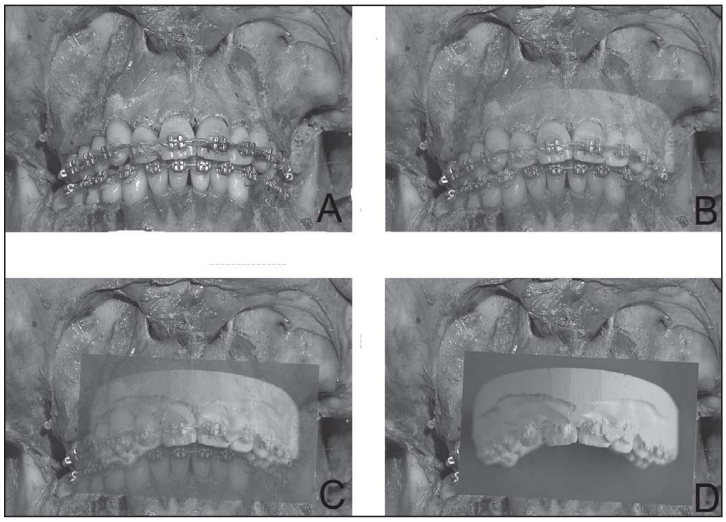

Image 8: Dental superimposition with an antemortem model [28]

1.5 Ethical and legal issues of cranio-photographic superimposition

There are many people ethically involved when performing cranio-photographic superimposition. One of these individuals are the family members of the victim, that are the ones that usually give to the forensic anthropologist and odontologist the antemortem photographs, and all the people that provided some important data regarding the deceased person. Furthermore, there are all those individuals involved in the study of the retrieved body that are the professional researchers, the ones that organized the project and the forensic team [12].

When performing any type of examination and analysis of a dead human body is important to treat it with dignity and maximum regard since even after death it still remains a person. This idea is also explained in The Universal Declaration on Bioethics and Human Rights [12].

The members of the family of the victim are crucial for the entire procedure because they actually are the ones that give some key tools and data to identify the person making all the process easier and quicker. Of course, this people help us in a very sad and traumatic situation for them so is fundamental to provide them the help they need especially from a psychological point of view [12].

The other ethically involved group of individuals are the ones that carry out the investigation. They have to respect the victim when manipulating the remains by trying to develop the most professional research with the use of their knowledge and experience and always following the laws and rules. The team has to be trained to act with the application of the International standards. They have to proceed and follow the principle of respect of autonomy, beneficence, non-maleficence and justice [12].

The process of performing cranio-photographic superimposition has to obey to the legislation of the country in which the study is applied like the EU one of the Charter of Fundamental Rights, Decision N°1982/2006/EC declared by the parliament on the 18th of December of 2006 regarding the 7FP for activities of demonstration, technology and research (2007-2013) and the Council occurred on the 24th of October of 1995 focusing on the personal protection and manipulation of data. Another important rule to obey is the one in which the researchers must reach a Research European Agreement approval of study once the committees of national or local ethics are accepted [12].

There must be an informed consent and the protocols have to be respected when performing this type of examinations [12].

2. OBJECTIVES:

1. The main primary objective is to describe the importance of cranio-photographic overlay in forensic identification
2. The secondary objectives are:
    2.1 Compare cranio-photographic superimposition techniques with / without dental structures
    2.2 Compare cranio-photographic superimposition with other necro-identification methods

3. METHODOLOGY:

To conduct this research thirty-three articles and two books have been examined in detail in order to find the most accurate and reliable information regarding cranio-photographic superimposition. To develop this study the references that have been selected comprehend a period of time that goes from the 1986 until the 2019 since it is a technique that has been studied since the early decades of the 20th century. The articles that have been published more that 10 years ago have been chosen because they are the first ones that started explaining the technique of cranio-photographic superimposition and its importance in the necro-identification field.

The databases used to find all the information needed to perform this work were: PubMed, Medline Complete, Google Scholar and Academic Search Ultimate.

Some key words like: cranio-photographic superimposition, craniofacial superimposition, forensic dentistry, identification, skull landmarks, video superimposition and computer-mediated superimposition have been introduced in the databases previously listed in order to find the most suitable and up-to-date articles and books to develop this research. The references that have been found were mainly in English language with the exception of two Spanish articles.

Below there is a table that summarizes the references used for this research containing the books and articles that have been thoroughly analyzed.

Topic of the Journal	***Title of the Journal / book***
Forensic Medicine	Journal of Ambient Intelligence and Humanized Computing
	Journal of Forensic Sciences
	Forensic Science Medicine and Pathology
	The New England Journal of Medicine
	Forensic Science International: Synergy
	Cuadernos de Medicina Forense
	Forensic Science International
	Journal of Forensic Research
	Forensic Science Research
	Craniofacial identification [book]
	Handbook on Craniofacial Superimposition [book]
Forensic Odontology	IATTS Research
	Journal of Forensic Dental Sciences
	Journal of Dental Problems and Solutions
	Journal *of* Forensic Odonto-Stomatology
Dentistry	Revista Mexicana de Estomatología
	Open Journal of Stomatology
	British Dental Journal
Medicine	The Anatomical Record
Biomedical Sciences	International Journal of Biomedical Science
Legal Medicine	Legal Medicine
	International Journal of Legal Medicine

Table 1: Division of the references used for the study

4. DISCUSSION

Through the years cranio-photographic superimposition aroused the interest of many authors that studied in detail the importance of this technique also in comparison to the other forensic methodologies usually applied in cases where the identification of a corpse is hard to develop.

Damas et al. in their book expose the successfulness of this forensic procedure showing how through history it has been crucial for many cases like the famous one regarding the identification of the doctor Mengele or many other disaster victim identifications [12].

According to Campomanes-Álvarez et al. cranio-photographic superimposition is a very useful and fundamental technique that can be used when the other procedures cannot be applied due to many interacting factors. These methods of identification like dactyloscopy, DNA analysis or dental analysis cannot be used in cases in which the retrieved body is in a very critical condition and only the skeletal part can be examined. In these occasions the cranio-photographic overlay becomes a perfect and effective option. The authors also show an aspect that must be considered when this forensic methodology is applied since the part of the orientation of the ante-mortem and post-mortem photographs may be very challenging and it takes a long time to develop because the positioning of the cephalometric and craniometric landmarks is not immediate to achieve [3].

Wilkinson et al. in their article agree with this idea and focus also on the relevance that cranio-photographic overlay has in the medico-legal field describing its importance in positive identification also adding that is a method now accepted all around the world. They also refer to the point introduced before by the other authors regarding the use

of this method whenever the other identification techniques cannot be taken into account reporting that is not always important how the corpse is retrieved but also how are the ante-mortem data that the forensic team find because many times the data are insufficient or not enough accurate to be used. The success of cranio-photographic superimposition depends on the quality of the data found because the pictures must have a good focus and must be at least two in order to be reliable; one must show the maxillary incisors and the other one must be with the mouth closed. The fact that the teeth are present in the picture makes the technique individualizing and useful for the positive identification of the victim [8].

In the article of Damas et al. this concept that multiple photographs are necessary to have an accurate result is also thoroughly explained. They add the idea that cranio-photographic superimposition is mostly used for exclusion than for positive identification since many times can lead to false positives. Furthermore, they describe that there is around 9% of misrecognition whenever only one ante-mortem photograph is analyzed but this percentage lowers to less than 1% when the forensic team analyses more than a single picture and all from different angulations [10].

Ubelaker in his work reinforces the idea that this method of identification is very powerful if is needed an exclusion, in other words, when the comparison of the ante-mortem data with the post-mortem data arises many differences and exclude that the person is not the same allowing to save time and money to further investigate on the suspected person. The author adds that is this type of technique what would really make a change would be to have a database where there are many facial images so that the identification would become quicker and easier to achieve [9].

Tinoco et al. In their article concentrate again on the importance of having good ante-mortem data because when these are inaccurate, the superimposition of photographs becomes a pivot tool to reach the positive identification but only whenever the picture of the person done before death shows the teeth with all their peculiarities and anomalies [33].

To strengthen this concept also da Silva et al. describe in their research that the recognition of a victim may be possible if there are also the individualizing elements that in this case are the teeth with their characteristics like diastemas, overbite and overjet and if all these factors are visible in the ante-mortem picture then if there is a coincidence, the possibility that the person is the same is sure. For example, if in the picture done before the person is deceased there is a clear missing central incisor and, in the photograph done on the skull when the body is retrieved the teeth is still not present, then, the correspondence becomes really high and together with other features may lead to a certain positive identification of the cadaver [34].

Pushparani et al. in their article also discuss about this method of identification and highlight its importance in necro-identification remarking the possibility to have some misidentification cases but again, they repeat the concept that if there are dental records collected from the ante-mortem picture, the definitive identity could be reached [29].

According to Raymond et al. the individual tooth anatomy studied comparing the ante-mortem and post-mortem data is very relevant for the identification of the victim. Furthermore, they explain how the superimposition of photographs has been used to reach an effective positive identification [31].

De Angelis et al. focus their research on the dental superimposition highlighting its importance. They also present the problem that nowadays for example Italy is experiencing regarding the large influx of foreign people, mainly immigrants, that reach the European countries without having any type of documentation and unfortunately when it happens the death of one of them the recognition becomes very challenging but thanks to the dental tissues and the overlay technique, the identification becomes possible. So, as even the previous authors explained, whenever there is the implication of teeth in the craniofacial superimposition technique, the method becomes individualizing [32].

Ibáñez et al. in their work expose the problem that arises when cranio-photographic superimposition is analyzed and is the fact that the reliability of this technique is not that strong since it lacks a standardized protocol to follow and is also due to this reason that is not always considered as the main method when there is the necessity to identify an unknown victim. They then introduced the MEPROCS (New Methodologies and Protocols of Forensic Identification by Craniofacial Superimposition) project to obtain a common guide to follow in order to reach a reliable craniofacial superimposition. In the countries that are less developed the cranio-photographic overlay is one of the most used tools due to the high quantity of criminal processes that arise every day and due to the fact that it is very inexpensive compared to the other identification techniques. In the other part of the world, especially in the more developed countries, it is less and less used since there are other valid methods that have the advantage of having a consolidated specific guideline to follow [35].

Even Huete et al. describe this MEPROCS project in their article explaining that the problem of cranio-photographic superimposition is the fact that who plays the most

important role in this procedure is the person who is conducting the process of overlay since there are no guidelines to follow as previously mentioned in the previous article. The main issue is that the expert in charge can have lack of knowledge or problems in the application of the technique with the subsequent failure in creating an effective superimposition. This is why is so fundamental to create a common and standard protocol to follow when developing craniofacial superimposition. In the MEPROCS project the authors tries to overcome the limits of this technique by listing the different errors and thoroughly describing the requirements and what the forensic team must avoid in order to perform the best and most reliable cranio-photographic superimposition. Thanks to these new guidelines this method will become more valid and authentic leading to a more frequent election of this procedure comparing it to many others since it has many advantages compared to the other more expensive systems of identification [27].

It is a topic that for sure will continue to be thoroughly discussed and analyzed because it has a very long background and because it has led to many successes in the criminal field. It is certain that cranio-photographic overlay will continue to generate the interest of many experts also in the future generations because it really can be a crucial tool for many complex situations in the field of forensic investigations.

5. CONCLUSION

1. Cranio-photographic overlay is a very useful and fundamental tool for necro-identification. It is not always the first choice when a victim is unknown, but it can be a good starting point to achieve either approximation or exclusion. Furthermore, it allows to save time and is economically convenient. It is a technique that has been used for decades without ever stopping because it can be essential for the identification of a human body, especially if found in very bad conditions like in an advanced state of decomposition. Rather it is used the photographic superimposition, the video superimposition or the computer-mediated one, the result would be in all the cases very reliable and effective even though the orientation process can be sometimes hard to achieve in the correct way.

2. This method can be considered as a general identification technique since it is not always possible to add to the study the dental elements rather because they are not present in the ante-mortem data, or because are not available in the post-mortem remains due to the condition in which the body is retrieved. In the cases where teeth can be analyzed too, this method becomes individualizing since teeth have unique features for every human being; for this reason, they are considered excellent tissues to study and to use for the positive identification of a corpse. So, when the ante-mortem photographs show the person smiling or at rest but with the teeth clearly visible, the superimposition would be much more reliable, valid and successful.

3. Cranio-photographic superimposition, compared to the other necro-identification techniques can be considered as useful as the other individualization method when the dental tissues are present but less specific when the teeth are not involved, in those cases it can only be used for a general approach while for the exact identification other methods like DNA studies, radiographies and dactyloscopy can be much more effective and reliable. This technique can unfortunately generate some false positives due to the fact that the correct angulation, position and magnification of the ante-mortem photograph with the post-mortem one, especially when the dental structures are not available, results very challenging. Furthermore, the limit that this method has, compared to the other ones is that it does not have a standardized protocol that leads to a lower degree of reliability.

6. SOCIAL RESPONSIBILITY

Cranio-photographic superimposition has a strong social importance since thanks to this technique, especially when there are also teeth present, it is possible to identify the unknown victim and subsequently give the body a name, an identity and most of all return the dignity it deserves. It is then ethically and legally fundamental to recognize the person that has deceased because not trying to identify the corpse would be disrespectful for both the victim and the relatives that would remain in the doubt of not knowing if their beloved person is still alive or not for their entire existence. Cranio-photographic superimposition has been used many times, from a single identification of a body to a situation where many victims have to be identified like in major catastrophes and in general in any case where the identification becomes complicated and this technique can play a key role to approach to the positive result.

Forensic dentistry may apparently not be affecting a general dentist since is true that is not common to be called to be part of a team in the recognition of a cadaver, but actually what is not really known is that dentists have a great responsibility since their daily practice will have repercussions in the possible future identification of a person. The medical history, the medical records, the dental radiographies, the odontograms, periodontograms and every information that the dentist collects results essential in forensic dentistry. Many times it can be all thanks to the role of the dentist, its knowledge and study of the ante-mortem data that a person is positively identified or not. So, it is important to understand the utility of dentist's work and accuracy in the records collected because the help it can give may be crucial in the necro-identification of an unknown human body.

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8.ANNEXES

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Odontology as a forensic science, the North American experience

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ABSTRACT

This chapter discusses the North American situation, primarily that of the United States judicial system.

The United States was established as neither a monarchy nor a theocracy. An unofficial motto of the country has always been – the rule of laws, not of men (or deities). The primary source of law in the United States is the US Constitution. However, each of the 50 states has as its primary source of law a state constitution. In order to become a state, that constitution must conform to US Constitution.

In the United States the US Congress, consisting of duly elected Representatives and Senators from the 50 states draft and pass Acts that establish (or direct to be established by officers of the Executive Branch following prescribed administrative procedures) federal law. Each state too, has its own legislative bodies and process for making law. Each state also has its own system of courts.

In order to discuss the role of the odontologist within these systems, a primer on how these systems function and interact is crucial.

This article discusses the functioning of those systems in relation to the practice of forensic odontology.

This chapter discusses the North American situation, primarily that of the United States judicial system. The reader is reminded that not only do Mexico and Canada have differing and independent systems of justice, but the United States is composed of just that – 50 semi-autonomous governmental systems – as well as the District of Columbia and several territories and possessions subject to federal law. The United States was established as neither a monarchy nor a theocracy. An unofficial motto of the country has always been – the rule of laws, not of men (or deities). The 13 original colonies bordering the Atlantic coast of the "New World" brought over from their mostly English heritage the concepts of the 11th century Magna Carta and the ancient tenets of the common law.

Those colonies who won their freedom from the British Empire in 1783 with the signing of the Treaty of Paris established a short-lived federation originally adopted in 1777, the Articles of Confederation. This fledgling government was completely reorganized into a democratic republic with the ratification of the Constitution of the United States of America and the Bill of Rights (its first 10 amendments) in 1787. The Judiciary Act of 1789 established the federal court system. The primary source of law in the United States is the US Constitution. However, each of the 50 states has as its primary source of law a state constitution. In order to become a state, that constitution must conform to US Constitution.

In the United States the US Congress, consisting of duly elected Representatives and Senators from the 50 states draft and pass Acts that establish (or direct to be established by officers of the Executive Branch following prescribed administrative procedures) federal law. Each state too, has its own legislative bodies (Nebraska maintaining the sole unicameral legislative body) and process for making law. Each state also has its own system of courts.

In order to discuss the role of the odontologist within these systems, a primer on how these systems function and interact is crucial. No state constitution can restrict rights granted by the US Constitution. No federal law or regulation can abrogate the US Constitution. Similarly, no state (or municipal) statute or regulation can restrict federally guaranteed or state guaranteed constitutional rights. An individual state constitution can provide its citizens greater rights than those offered by the US Constitution and neither federal nor state laws nor regulations can restrict those rights. Who then decides what rights, if any, have been abridged and which system trumps which?

The judiciary, the court, is charged with this duty. Again, it is important to understand the jurisdiction and sweep of the many different types of courts found within America. There are two independent systems of courts within the United States. The federal courts enjoy absolute jurisdiction over federal matters – questions involving US Constitutional law, interpretations of federal statutes and regulations, disputes arising between state governments or between states and the federal government, or certain disputes arising between citizens of different states. These cases may arise in either criminal (offense against the public) or

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Overview

Victim identification in large-scale disasters using dental findings

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ABSTRACT

Recently, personal identification based on dental findings (PIDF) has been proven to be a useful and accurate technique. This approach involves the treatment of the 5 surfaces of the 32 teeth in adults. The rate of mismatch between a target an individual is significantly low in the event of multiple dental treatments. In some cases, an individual may be recognized based on their morphological features without the need for dental analysis.
PIDF has proven to be highly effective when human remains are unidentifiable e.g. skeletal, decomposed, burned and partial remains, etc. However, if the features of a victim are recognizable, identification should be performed based on facial feature or fingerprints.
PIDF is particularly useful when there is a heavy toll on human lives. A large-scale disaster is a typical case for the application of this method. In this report, the utility of PIDF and their application are presented using geographic and Japanese domestic transportation cases.

1. Introduction

The term “train accident” began to be used since the time the steam engine with steel wheels was used for freight transportation. Further, the term airplane crash was coined after the first flight of Wright Flyer by the Wright brothers, Wilbur and Orville in 1903.

The first airplane crash occurred during a flight demonstration of the Wright flyer in 1908. This was 5 years after the first flight of the Wright flyer. Subsequently, the air crash of Daimler airways and Gran Express Adrianna occurred. To date, approximately 630 (this number does not include air crashes that occurred in war, Cessna and helicopter crash, etc.) airplane crashes have occurred since the people begun to used the way of air transportation (Table 1). So far, 18 airplane crashes (3.4%) have occurred in Japan (Tables 2 and 3). The largest single airplane accident is included in this number.

It is, however, difficult to quantify the number of train accidents that have occurred in the world to date. This is because train networks are spread throughout the world and each nation has its own specific network. Further, compared to airplane crash, there are many types of train accidents, for example, derailment, accidents at train crossing, and passenger fall.

In this paper, the author provides additional information on a previous study [1] reports on disaster victim identification by taking examples of two famous cases of crash in Japan.

2. Disasters

Disaster is commonly recognized term in Japan. The term “disaster” refers to the damage that results from a storm, tornado, heavy rainfall, heavy snowfall, flood, slope failure, mudflow, high tide, earthquake, tsunami, volcanic eruption, landslide, or other abnormal natural phenomena including large fires, explosions or other causes provided for by Cabinet Order and similar to the aforementioned examples in the extent of the damage they cause; according to the Disaster countermeasure basic act (Act no 223 of November 15, 1961) of Japanese government. This act categorizes a disaster based on the associated phenomenon e.g. tsunami, earthquake, explosion etc. However, the precise definition of the scale of a disaster has not been articulated by the government of Japan. Classically, disasters can be divided into two categories, “natural disaster” and “human-made disaster”. Natural disasters include meteorological (cyclone etc.), geological (tsunami etc.) and biological (pestilence etc.). Human-made disaster can be subdivided into urban disasters (fires etc.), industrial accidents (occupational accidents etc.), transport disasters (airplane crashes, train derailments etc.), management disasters (inferior construction etc.), environmental hazards, conflict disasters (disaster due to environmental destruction), and CBRNE disasters (chemical, biological, radiological, nuclear and explosive). Occasionally, the subgroupings can be “onset” and “duration”. A flash flood often causes drowning and trauma, which may result in widespread infections after a week. Although, these categorizes includes many disasters, they do not provide information on the scale and the numbers of victims. [2] In recent years, disaster can be divided into “Open disaster” and “Closed disaster”(Fig. 1), on the basis of the assumption that the disaster causes many specific and nonspecific victims.

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ORIGINAL RESEARCH

Computer-based craniofacial superimposition in forensic identification using soft computing

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Abstract One of the most important tasks in forensic anthropology is human identification. Over the past decades, forensic anthropologists have focused on improving techniques to increase the accuracy of identification. Following a thorough examination of unidentified human remains, the investigator chooses a specific identification technique to be applied, depending on the availability of ante mortem and post mortem data. Craniofacial superimposition is a forensic process in which photographs of a missing person are compared with a skull in order to determine whether is the individual depicted and the skeletal remains are the same person. After more than one century of development, craniofacial superimposition has become an interdisciplinary research field where computer science has acquired a key role as a complement of forensic sciences. Moreover, the availability of new digital equipment has resulted in a significant advance in the applicability of this forensic identification technique. In this paper, we review a semi-automatic method devised to assist the forensic anthropologist in the identification process using craniofacial superimposition. The technique is based on a three-stage methodology. The first two are performed automatically by soft computing techniques. However, the final decision corresponds to the forensic expert. The performance of the proposed method is illustrated using several real-world identification cases.

Keywords Forensic identification · Craniofacial superimposition · Skull 3D model reconstruction · Skull-face overlay · Evolutionary algorithms · Fuzzy landmarks

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1 Introduction

Forensic anthropology studies medico-legal questions related to a deceased person through the examination of his skeletal remains (Burns 2007). The use of various identification techniques such as fingerprints, DNA profiles, or dental data comparison, depends mainly on the availability of information pertaining to a missing person and the condition of the remains to be compared, oftentimes, in missing persons cases, in mass graves or in mass fatalities, the available data is scanty (Iscan 1981). Hence, anthropological identification based only on skeletal information can be considered as the last resort for forensic identification. In this case, more specific skeleton-based identification techniques are alternatively implemented.

Among them, craniofacial superimposition (CS) is the most relevant technique (Krogman and Iscan 1986; Iscan 1993; Taylor and Brown 1998; Stephan 2009). This method aims to compare photographs of a "missing person" with a skull by superimposing photographs of the skull and of the missing person to establish whether they are same person by matching anthropological landmarks defined in the literature (Martin and Saller 1966).

These landmarks are located in two objects of different nature; the skull found, and the available face photograph

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REVIEW

Disaster victim identification: quality management from an odontology perspective

A. W. Lake · H. James · J. W. Berketa

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Abstract The desired outcome of the victim identification component of a mass fatality event is correct identification of deceased persons in a timely manner allowing legal and social closure for relatives of the victims. Quality Management across all aspects of the Disaster Victim Identification (DVI) structure facilitates this process. Quality Management in forensic odontology is the understanding and implementation of a methodology that ensures collection, collation and preservation of the maximum amount of available dental data and the appropriate interpretation of that data to achieve outcomes to a standard expected by the DVI instructing authority, impacted parties and the forensic odontology specialist community. Managerial pre-event planning responsibility, via an odontology coordinator, includes setting a chain of command, developing and reviewing standard operating procedures (SOP), ensuring use of current scientific methodologies and staff training. During a DVI managerial responsibility includes tailoring SOP to the specific situation, ensuring member accreditation, encouraging interdisciplinary cooperation and ensuring security of odontology data and work site. Individual responsibilities include the ability to work within a team, accept peer review, and share individual members' skill sets to achieve the best outcome. These responsibilities also include adherence to chain of command and the SOP, maintenance of currency of knowledge and recognition of professional boundaries of expertise. This article highlights issues of Quality Management pertaining particularly to forensic odontology but can also be extrapolated to all DVI actions.

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Keywords Disaster Victim Identification · Forensic odontology · Quality management

Forensic Odontology involves recognizing, collecting, preserving, examining, recording, analyzing and reporting of the dental and surrounding anatomical structures. Quality Management in forensic odontology is the understanding and implementation of a methodology that ensures collection, collation and preservation of the maximum amount of available dental data and the appropriate interpretation of that data to achieve outcomes to a standard expected by the Disaster Victim Identification (DVI) instructing authority (lead agency), involved parties, and the forensic odontology specialist community. Lead agencies are generally police, judicial administrators, government agencies or military entities. The directly or indirectly involved parties include family, friends and business associates of suspected victims, the DVI participating specialist personnel, the legal system of the particular jurisdiction in which the incident occurred, and also its impacted community. Quality Management expectations of all these groups might not be identical [1, 2] and therefore it is important that internationally accepted basic standards are available as a model.

Personal identity during life is composed of an infinite number of features both physical and mental and all of them more or less characteristic [3]. Following death and the effect of traumatic and environmental influences, many of these characteristics change or are destroyed. Dental, fingerprints and DNA are widely recognized as primary identifiers since these are considered the most likely to remain intact and measurable using currently available scientific methodologies [4, 5]. In numerous DVI investigations single primary identifiers have been able to stand alone in providing a match between a missing person and

Forensic odontology, part 4. Human bite marks

J. Hinchliffe[1]

IN BRIEF

- Increases understanding of bite mark analysis.
- Underlines the importance of appropriate evidence collection, management, preservation, analysis and interpretation.
- Highlights the benefit of advancements in digital technology.
- Emphasises the importance of exercising caution with opinions and conclusions.

GENERAL

The aim of this paper is to give a brief overview of bite mark analysis: its usefulness and limitations. The study and analysis of such injuries is challenging and complex. The correct protocols for collection, management, preservation, analysis and interpretation of this evidence should be employed if useful information is to be obtained for the courts. It is now possible, with advances in digital technology, to produce more accurate and reproducible comparison techniques which go some way to preventing and reducing problems such as photographic distortions. Research needs to be continued to increase our knowledge of the behaviour of skin when bitten. However, when presented with a high quality bite mark showing good dental detail, and a limited, accessible number of potential biters, it can be extremely useful in establishing a link between the bitten person and the biter or excluding the innocent.

INTRODUCTION

The examination and analysis of bite marks is used in an attempt to scientifically link the dentition of a potential biter with a bite mark. The bite mark may be found on skin or some other material, and crime scenes must be thoroughly searched in order to find bitten objects that may link a biter to a crime scene: a bitten piece of cheese found at the murder scene, along with other evidence, helped secure a conviction of the murderer of three family members after a wedding in the UK in 1983. Bite mark evidence has been used with increasing frequency over the years, possibly due to raised awareness and recognition of such injuries (from a multidisciplinary approach), along with an increase in the number of domestic violence and abuse cases reported, many of which involve biting injuries.

Bite mark analysis methods have evolved over the years to give more reliable and reproducible results. However, the behaviour of skin and the underlying tissue during the dynamic biting process is still not clearly understood and caution with the interpretation of (and conclusions drawn from) these injuries is essential if this evidence is to be useful and acceptable to the courts. A few controversial cases involving biting injuries have emphasised the need for standardised protocols, appropriate training and carefully considered opinions and conclusions.

SOME CONSIDERATIONS

The complexity of biting injuries and their analysis and interpretation makes them a great challenge even for the most experienced forensic odontologist.[1] Human bite marks can be found on the skin of the living or deceased, adult or child, victim or suspect. They can also be found on inanimate objects such as foods,[2] wood, leather, or other substances. Beware the self-inflicted bite and the so-called amorous or 'love' bite.

Sexual assaults, fights, homicides and abusive incidents often result in biting injuries and the necessity to involve the forensic odontologist. Sometimes it may be necessary to differentiate a bite caused by a human dentition from that caused by an animal. For example, worried neighbours called the police when they saw an 18-month-old child in the next door garden, covered in bruises. On examination, five of the injuries were confirmed as human bite marks. The child's mother and boyfriend said the bites must have been inflicted by the dog next door (a good example of the injury not being explained by the history given). Following bite mark analysis, the mother (and dog!) could be excluded from causing the bites; the boyfriend could not.

A bite mark may be defined as a representative pattern left in an object or tissue by the dental structures of an animal or human. This article will limit discussion to those bites caused by the human dentition on skin.

It is essential to ensure that evidence relating to the injury is documented, collected, preserved, analysed and interpreted following appropriate protocols and using scientifically accepted techniques. Teamwork is essential for the correct management of evidence from these injuries and may involve police, crime scene investigators, pathologists, forensic odontologists and DNA personnel. Legal teams may present the evidence to the courts, as this type of evidence is admissible in several countries. Conclusions must be carefully considered and free from personal bias, and may support or refute a conviction; getting it wrong may lead to a miscarriage of justice and incarceration of an innocent person (or release of the guilty): not acceptable.

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Experimental studies of forensic odontology to aid in the identification process

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Abstract

The importance of dental identification is on the increase year after year. With the passage of time, the role of forensic odontology has increased as very often teeth and dental restorations are the only means of identification. Forensic odontology has played a key role in identification of persons in mass disasters (aviation, earthquakes, Tsunamis), in crime investigations, in ethnic studies, and in identification of decomposed and disfigured bodies like that of drowned persons, fire victims, and victims of motor vehicle accidents. The various methods employed in forensic odontology include tooth prints, radiographs, photographic study, rugoscopy, cheiloscopy and molecular methods. Investigative methods applied in forensic odontology are reasonably reliable, yet the shortcomings must be accounted for to make it a more meaningful and relevant procedure. This paper gives an overview of the various experimental studies to aid in the identification processes, discussing their feasibilities and limitations in day-to-day practice.

Keywords: Age estimation, cheiloscopy, experimental studies, forensic odontology, molecular methods, rugoscopy, sex determination, tooth prints

Introduction

Human identification is one of the most challenging subjects that man has been confronted with. The forensic discipline is concerned with the application of science and technology to the detection and investigation of crime and administration of justice, requiring the coordinated efforts of a multidisciplinary team.[1] Dental identification remains one of the most reliable and frequently applied methods of identification, predominantly by the comparisons of ante-mortem and post-mortem records.[2] The science of dealing with evidence from dental and oral structures – Forensic Odontology, is a specialty unto itself. The establishment of forensic odontology as a unique discipline has been attributed to Dr. Oscar Amoeda (Father of Forensic Odontology), who identified the victims of a fire accident in Paris, France in 1898 [Table 1].[3] This branch has an established domain with wide applications in:

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Review Article

Dental Identifications of Adolf Hitler and Eva Braun

Really Bad Teeth

Hitler [1] had very bad teeth and a very bad breath. Before the war, he asked Blaschke, his dentist, to immobilize his teeth with a dental bridge. He wanted that bridge to be placed for several years. Thus, Blaschke made an unusual and easy-to-recognize solid metal bridge.

End of war…Beginning of the investigation…

On April 30, 1945, Hitler committed suicide. His body was burnt in a bomb crater in the garden of the Chancellery next to a hospital and amongst other corpses which were buried afterwards.

Despite the investigation of British officer Trevor-Roper and despite being approached diplomatically, the Russians did not answer any questions concerning this affair until 1954. It was only that year, when Blaschke's dental prosthetist, Fritz Echtmann, was realeased from prison, [2]; –he had been interned in Russia for nine years- that the entire world learnt about the exact fate of the Führer and his wife. On October 15, Echtmann stipulated that he had been arrested by the Russian secret services on May 9, 1945 in his house in Berlin. On the same year, once she was also released and back from Russia, Blaschke's assistant, Käthe Heusermann [3] attested to also have been arrested on May 9, 1945.

Post-mortem examinations

The Führer's body was only found again on May 3, 1945 by Smersh agents, the counter-intelligence department in the Soviet Army. On May 8, he was brought in a hospital of Berlin's suburbs to be examined. On May 9, his dentures (Figure 1) found on the cadaver were shown to the assistant of Hitler's personal dentist [2] and to the dental mechanic who had made them. Echtmann [4] recalled that the Soviets had shown him a lower jaw which had been cremated with two gold bridges and another one divided into nine pieces which was also in gold and which was coming from his jawbone. Indisputably, he remembered the work he did for Hitler. He was shown a gold-filled bridge, which was similar to that of the mandible that Eva Braun used to wear. When he was imprisoned, he submitted an additional nine-page report on the matter.

In the same time, the assistant identified the various elements of dental prosthesis that were being shown to her. Both of them remembered well the red box in which Hitler's remains were stored, and of the tall blond interpreter who permitted discussions with the Russians.

Those two statements were published and yet, doubts remained. The need of an official report without flaws and coming to an indisputable and irrefutable conclusion became obvious.

First public revelations

In 1965, Yelena Rzevskaya, the blond interpreter whom Echtmann and Heusermann mentioned, published a report entitled «Berlin, May 1945» in a Soviet magazine. This work was published as a book and translated into numerous languages in 1967. This work told how the Russians discovered thirteen charred corpses in the gardens of the Chancellery, how, in the following days; they were examined by a

Figure 1: Fragment of Adolf Hitler's mandible [14].

Figure 2: : Etchmann's sketch of Eva Braun's left side teeth [8]. To the left, the bridge that was never inserted.

THE USE OF CRANIOFACIAL SUPERIMPOSITION FOR DISASTER VICTIM IDENTIFICATION

ABSTRACT

Skull-to-face comparison is utilised for human identification where there is a suspected identity and the usual methods of identification, such as DNA or dental comparison, are not possible or practical. This research aimed to compare the reliability of manual and computerised craniofacial superimposition techniques and to establish the application of these techniques for disaster victim identification, where there may be a large database of passport-style images, such as the MPUB Interpol database. Twenty skulls (10 female; 10 male) were utilised from the William Bass Skeletal Collection at the University of Tennessee and compared to face pools of 20 face photographs of similar sex, age and ethnic group. A traditional manual photographic method and a new 3D computer-based method were used. The results suggested that profile and three-quarter views of the ante-mortem face were the most valuable for craniofacial superimposition. However, the poor identification rate achieved using images in frontal view suggests that the MPUB Interpol database would not be optimal for disaster victim identification, and passport-style images do not provide enough distinguishing facial detail. This suggests that multiple ante-mortem images with a variety of facial expression should be utilised for identification purposes. There was no significant difference in success between the manual and computer methods.

KEYWORDS

Craniofacial superimposition, identification, disaster victim

INTRODUCTION

Facial anthropology involves biological analysis and interpretation of the skull and/or the face and can be applied to identification of the living (biometrics, image analysis) and the dead (facial depiction, craniofacial superimposition, osteology, anatomy)[1]. Craniofacial analysis of the dead can be utilised for single unidentified human remains, multiple victims of disasters and mass graves. In the majority of forensic investigations there will be a suspect in relation to identity; in single forensic cases there may be a missing persons list, in mass disasters there may be a closed list (such as a passenger list for a transport system) or an open list (reported missing by families and/or employers) and for mass graves there may be whole missing populations. In these circumstances there may be ante-mortem data available relating to the suspects and this might include biological profiles (age, sex, stature, ethnic group), personal information (body modifications, identifying marks, clothing, jewellery, hair style etc.),

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PAPER

ANTHROPOLOGY

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Craniofacial Superimposition: Historical Review and Current Issues*

ABSTRACT: Methodology of craniofacial superimposition has evolved dramatically since its inception in the early 20th century. Contemporary approaches involve advanced procedures of digitization, use of video cameras, warping algorithms, skull positioning devices and data derived from computed tomography, radiography, and ultrasound technology. Applications have proven most useful in exclusion and casework frequency has declined in some regions in recent years as molecular approaches to identification have become more widely available. Additional research is needed to clarify the probabilities involved and to facilitate comparisons when the technique is employed.

KEYWORDS: forensic science, craniofacial identification, skulls, photographs

Craniofacial superimposition refers to the process of comparing images of a skull recovered from forensic contexts to facial photographs of a once living person who might be represented by the skull. Historically, the technique has been employed when recovered remains are thought possibly to relate to a particular missing person, for whom photographs are available. Methodology and the nature of case applications have evolved considerably, especially within the past two decades. This evolution has been shaped by technology, advances in related areas of forensic anthropology and forensic science in general and recent focus by statisticians and specialists in morphometric analysis. These changes have occurred within the shifting global climate for the practice of forensic science that has become increasingly more critical of scientific methodology. This article reviews these historical changes and provides current assessment of the status and requirements for future advancement of this methodology.

The topic of craniofacial superimposition (CFS) has received considerable scholarly attention including key review treatment. Noteworthy among the summary articles are those by Aulsebrook et al. in 1995, Taylor and Brown in 1998, Glassman in 2001, De Greef and Willems in 2005, Ubelaker in 2007, Stephan in 2009, Ubelaker also in 2009, and Damas et al., 2011 (1–9). Important overviews of general issues in forensic craniofacial imagery have been provided by Clement and Ranson, 1998, Wilkinson, 2004, and Wilkinson and Ryan, 2012 (10–12). These works all provide important syntheses at the time they were written and make available useful information to supplement this article.

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History

The early history of the development of craniofacial superimposition is entwined with developments in facial approximation, also referred to frequently as facial reproduction (13). Although these two applications employ similar scientific information in the assessment of the relationship between the hard and soft tissues of the human head, they involve distinct methodology and purpose. Facial approximation represents the attempt to estimate the visual appearance of an individual from analysis of a recovered skull. In the forensic context, it is employed when a skull is recovered, thought to be recent and thus of forensic interest and attempts at identification using traditional methods have been unsuccessful. Facial approximation is then used to generate a facial image to present to the public, usually through the media, to solicit information on missing persons that might lead to identification.

The central issue in facial imagery in general and craniofacial superimposition in particular is the extent to which soft tissue facial anatomy can be predicted from the underlying hard tissue. The science relating to the early history of this issue predictably was generated by human anatomists who in general were both cautious and skeptical. For example, in 1918, the respected anatomist Adolph Schultz (1891–1976) reported on the relationship between the human bony nose and nasal cartilages (14). This work is presented using the racial typology of that era but presents a still useful summary of the existing literature relating to nasal structures. To seek clarification, Schultz dissected 36 human heads and devised an index relating soft tissue to hard tissue. This research led him to critically summarize "no conclusions concerning the breadth of the external nose can be drawn from the breadth of the aperture" (p. 332).

Other early anthropologists and anatomists remained critical in regard to the estimation of facial morphology from skeletal structure, especially in relation to the nose. In 1935, Suk (15, p. 43) reported on his head dissection of 16 corpses relating that the" bony nose does not tell us anything about the external nose

Forensic Identification by Computer-Aided Craniofacial Superimposition: A Survey

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Craniofacial superimposition is a forensic process in which a photograph of a missing person is compared with a skull found to determine its identity. After one century of development, craniofacial superimposition has become an interdisciplinary research field where computer sciences have acquired a key role as a complement of forensic sciences. Moreover, the availability of new digital equipment (such as computers and 3D scanners) has resulted in a significant advance in the applicability of this forensic identification technique. The purpose of this contribution is twofold. On the one hand, we aim to clearly define the different stages involved in the computer-aided craniofacial superimposition process. Besides, we aim to clarify the role played by computers in the methods considered.

In order to accomplish these objectives, an up-to-date review of the recent works is presented along with a discussion of advantages and drawbacks of the existing approaches, with an emphasis on the automatic ones. Future case studies will be easily categorized by identifying which stage is tackled and which kind of computer-aided approach is chosen to face the identification problem. Remaining challenges are indicated and some directions for future research are given.

Categories and Subject Descriptors: H.4.2 [**Information Systems Applications**]: Types of Systems—*Decision support*; I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems—*Medicine and science*; I.4.9 [**Image Processing and Computer Vision**]: Applications; I.5.4 [**Pattern Recognition**]: Applicatons—*Computer vision*; J.3 [**Life and Medical Sciences**]: Medical Information Systems

General Terms: Algorithms, Human Factors, Legal Aspects

Additional Key Words and Phrases: Forensic identification, craniofacial superimposition, photographic supra-projection, skull-face superimposition, photographic superimposition, video superimposition, skull modeling, decision making

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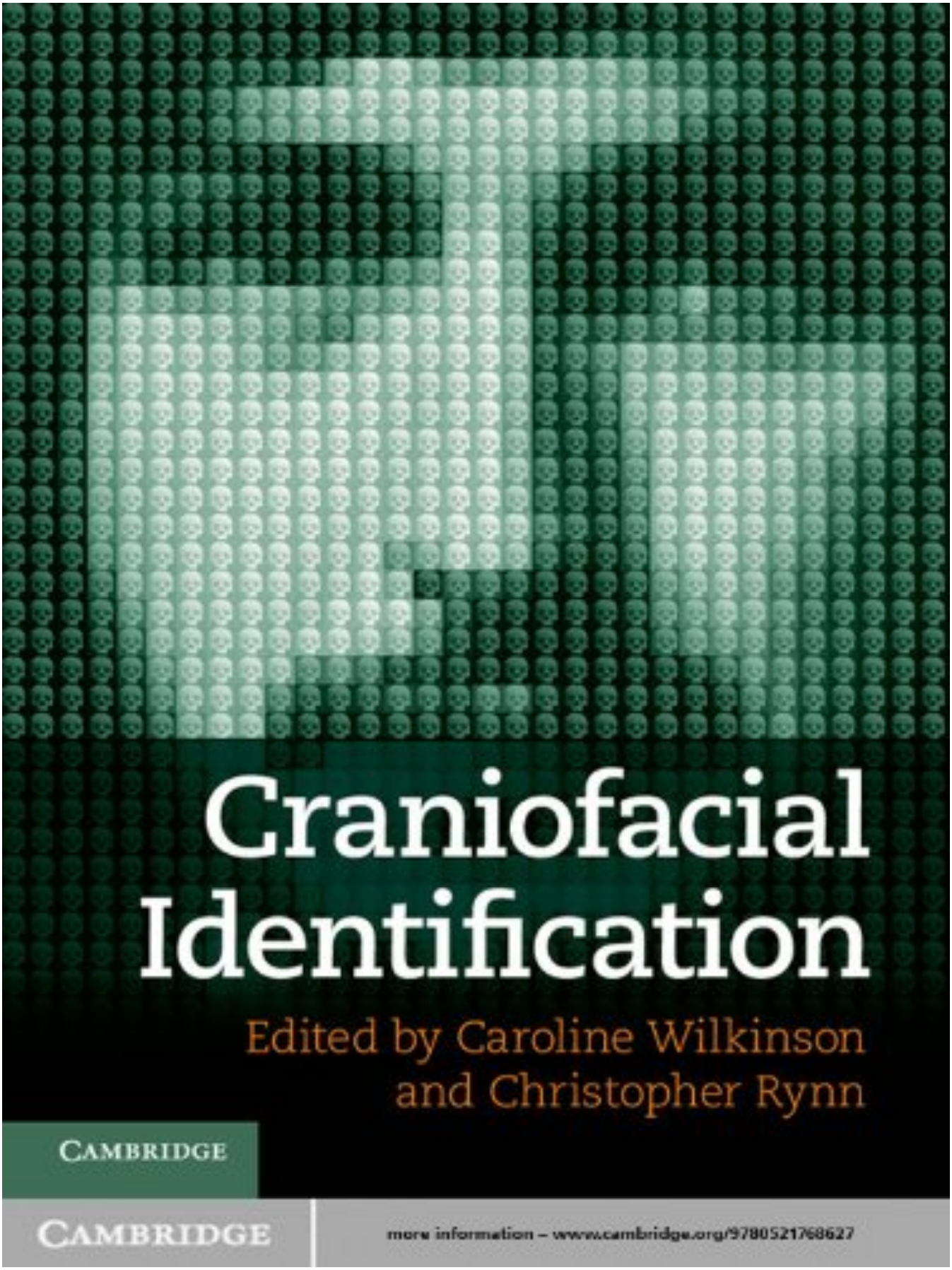
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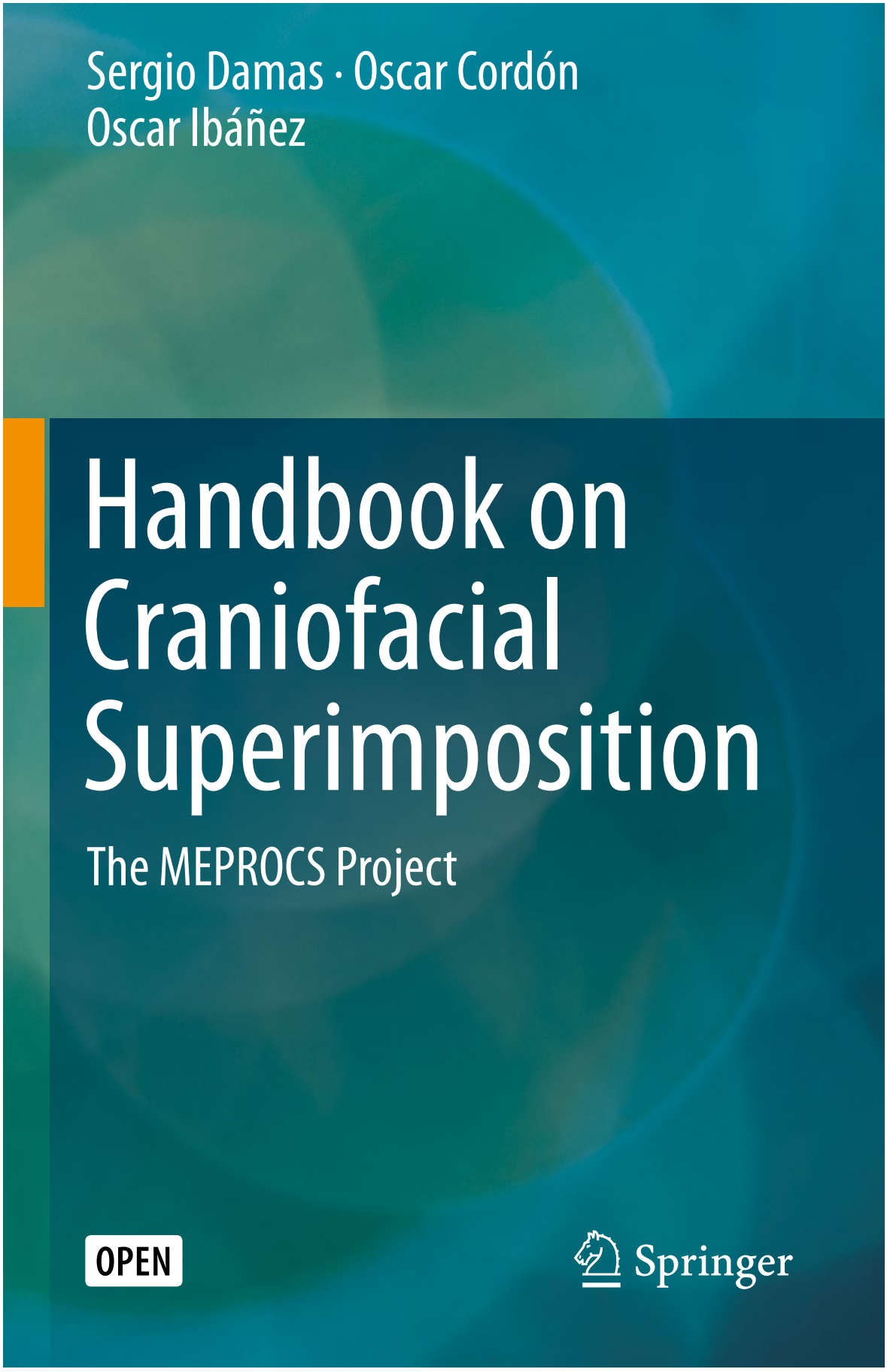
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MEDICAL INTELLIGENCE

LAW–MEDICINE NOTES

The Forensic Investigation of the Death of Josef Mengele

WILLIAM J. CURRAN, J.D., S.M.HYG.

AN important report has been published in a highly respected American journal of forensic pathology summarizing the conclusions of an international group of forensic scientists who gathered in São Paulo, Brazil, in June 1985 to help identify a man who had died in a swimming accident some five years earlier.[1] The man was buried under the name "Wolfgang Gerhard," but he was believed to be Dr. Josef Mengele, the most hunted remaining war criminal of World War II — the "Angel of Death" of Auschwitz, who was personally responsible for thousands of deaths, many under the guise of scientific biomedical experiments.[2]

The story of the search for Josef Mengele is as strange and contradictory as it is sensational. The news reports of mid-1985 gave the impression that Mengele had always been one of the most notorious of the war criminals and had been sought continuously and relentlessly since the war's end in 1945. On the contrary, Mengele was not one of the most hunted figures among the Nazi fugitives immediately after the war. The victorious allies had concentrated on the most obvious of the leaders and administrators of the Nazi party, the military, and the government, even when it was the physicians' turn to be tried, in late 1946. (The indictments were handed down on October 25, 1946.[3]) The chief defendant among 23 indicted physicians was Karl Brandt, the head of the national health and medical services and a personal protégé of Adolf Hitler. The trials against the medical leaders and administrators focused primarily on the deaths and mutilations due to experimental programs on behalf of the Armed Forces and on the prewar and wartime euthanasia program. Among the other defendants were several leading physicians in the Schulzstaffel (S.S.) of the Nazi Party who were responsible for administering the concentration camps. The most prominent was Karl Gebhardt, chief physician of the S.S., personal physician to the head of the S.S., Heinrich Himmler, and astonishing as it now seems, president of the wartime German Red Cross. Both Brandt and Gebhardt were among the seven physicians who received the death penalty for their crimes.

The medical defendants generally claimed one of two types of defense: (1) that they were merely acting under orders from higher authority, and (2) that the experimental activities were proper and justified as necessary scientific inquiries designed to aid the war effort. Much of the experimental work cited in the trials did relate to war activities, such as research on high-altitude exposure, sea-water exposure, incendiary-bomb explosion, and epidemic conditions such as jaundice, typhus, and malaria.[4] The first defense was uniformly disallowed throughout the trials but could be considered in mitigation of punishment in individual cases. The second defense caused the most searching legal and ethical inquiries of the entire "Medical Case." As a result, the prosecution produced the famous Nürnberg Code, a set of 10 principles of accepted practice in experimentation in humans, especially as applied to persons under constraint or imprisonment.[5,6] The first and most important of the principles was the requirement of free, informed consent of the experimental subject. The code produced at Nürnberg became the principal legal and ethical standard for all clinical investigations on a worldwide basis in the postwar years.[7] Not one of the defendants at Nürnberg was found to have complied with those principles.

Josef Mengele's name was not mentioned during the war-crimes trials. It was omitted for two reasons: first, he was not one of the high-level leaders of the Nazi party or the government structure; and second, his experimental efforts were of his own design and not related to an overall strategy or national conspiracy, as was alleged of the activities of virtually all the defendants. In my opinion, a trial of Mengele, with its narrower focus, would have presented great difficulties of proof in those early months of investigation after the war, when proof against even the major figures was not easily produced. By no means, however, were Mengele's crimes any less in number or heinousness. I have read the official records of the Medical Case against the 23 defendants and many other official and unofficial accounts of the medical atrocities in the concentration camps. None were worse than Mengele's. The undisputed accounts of his activities at Auschwitz are a revolting litany of depravity, torture, and death. Mengele is most often remembered by survivors as the swaggering, immaculately dressed captain of the S.S. who stood beside the railway cars after their arrival at the camp to select victims for his experiments.[8,9] Those he did not choose went immediately to their deaths in the gas chambers. Those he selected died more slowly at his hands in his laboratory. On several occasions, as he stood by the arriving freight cars of Jewish, Polish, Hungarian, and other discarded and condemned peoples of the Nazi-held territories in Eastern Europe, he took out his pistol and shot to death someone who offended him. Particular targets of his experimental zeal were twins and dwarfs. They died frightful, horrible deaths at his hands in senseless, purposeless experiments notable only for the precise detail with which they were recorded. In his laboratory were displayed openly the

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Craniofacial photographic superimposition: New developments

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ABSTRACT

Craniofacial superimposition is a technique used in the field of forensic anthropology to assist in the analysis of an unknown skull. The process involves superimposing an image of the recovered skull over an ante mortem image of the suspected individual. In the past two decades, there has been a decline in the application due to the development of molecular analysis as a more precise and accurate identification technique. Despite its decrease in use, there has been significant development in superimposition techniques in the past five years, specifically to standardize procedures. One project, MEPROCS (The New Methodologies and Protocols of Forensic Identification by Craniofacial Superimposition), has attempted to establish a framework for solving the problems of past superimposition techniques. Future researchers should consider integrating information gleaned from clinical practices with the statistical and technical advances of craniofacial superimposition for better facilitating its use in forensic anthropology.

The method of craniofacial superimposition involves comparison of features of a skull with antemortem photographs of a head and/or face. In the forensic context, photographic superimposition focuses on a recovered skull that likely is of sufficiently recent origin to be of medico-legal interest. Forensic scientists employ the technique when positive identification has not been accomplished but authorities suspect the recovered skull relates to a particular missing person. Analysis goals focus on determining if (1) the skull could not represent the person (exclusion), (2) the skull definitely represents the person (positive identification) or (3) the skull could represent the person. An exclusion indicates that features of the skull are inconsistent with features of the antemortem photographs to the extent that they could not represent the same person. Positive identification suggests that the skull and photograph share so many important features that they represent the same person to the exclusion of all others. The third category indicates that the skull and photograph share sufficient features that an exclusion is not possible but the shared characteristics are not sufficiently unique to allow a positive identification.

It should be noted that craniofacial superimposition should not be confused with techniques of facial approximation. Facial approximation involves estimating the facial appearance from a recovered skull usually to reach out to the public for information possibly leading to identification.

1. Perspective prior to 2015

Methods of craniofacial photographic superimposition have evolved dramatically since crude, early attempts dating back to 1931 (Ubelaker, 2015) [1]. Review articles by Aulsebrook et al. (1995) [2], Damas et al. (2011) [3], Yoshino (2012) [4] and Ubelaker (2015) [1] summarize the history of these developments and the issues encountered. These exhaustive reviews document progress through technological advancement (primarily computerization of the process) and new research documenting the relationship between hard and soft tissues of the head.

The vast literature on research developments and testing dating prior to 2015 is presented in the cited review articles and does not need to be repeated here. Examples of these publications include the Hadi and Wilkinson (2014) [5] study indicating that facial creases display postmortem resilience and can be important features for identification. Campomanes-Álvarez et al. (2014) [6] produced an automated procedure to reduce subjectivity by analysts. Ibáñez et al. (2009) [7] utilized evolutionary algorithms to enhance the process. Ibáñez et al. (2012) [8] introduced a cooperative coevolutionary approach to reduce the time involved and improve applications. Stephan and Davidson (2008) [9] and Stephan et al. (2009) [10] reported new research on anatomical placement of the human eyeball to facilitate comparison. Parzianello et al. (1996) [11] revealed an automatic system for detection of

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The identification of a dismembered human body: a multidisciplinary approach

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Abstract

A criminal case was directed to a multidisciplinary forensic team for identification, concerning a victim whose head, having two gunshot wounds, had been separated by a sharp instrument and was recovered 6 months later.

The purpose of this research was to determine the sex and age of the victim for human identification. Primarily, macroscopic examination of the skull, tooth, and DNA analysis was conducted for sex determination. A rough assessment of age was made from the skull based on anthropological findings, however a more definitive result of age estimation was determined utilizing dental morphology.

The dental data showed an age range of 32–37 from the mineral examination and the formulation of microscopic measurements. The results obtained from the skull and dental analysis matched with the physical characteristics of the victim's body, the known personal data of this person, and with the superposition of the photos gathered by a formal request. Besides, the result of DNA profiling of the victim showed male gender and direct relationship with the victim's presumed wife and daughter.

Generally, research on human identification consists of sex and age determination. The sex characteristics can be precisely proved from DNA tests. However, age can be estimated by skeletal, and dental analysis. In this case the performed sex and age analysis lead the research to the selective matching of the missing person's identity.

Keywords: Human identification; Skeletalization; DNA profiling; Dental age estimation; Case study; Dismembered remains; Skull–photo superimposition; Age estimation with SEM

1. Introduction

A basic step in resolving a criminal case is the identification of the victim. This is especially difficult when the remains are decomposed and skeletonized badly. As defined by Krogman and İşcan [1], the big four, age, sex, population affinity, and stature can provide the essential information to start a criminal investigation. To resolve such cases, a specialized team of forensic scientists including a medical examiner, anthropologist, biologist, and odontologist is required [2,3]. The skull and pelvis give a close determination of the sex [4]. Age estimation from the adult skeleton is more complex and requires a deeper understanding probably because of the increased variation in older individuals [5]. Therefore, the identification process may incorporate DNA analysis. The aim of this paper is to employ multidisciplinary techniques such as anthropology, odontology, and DNA profiling to identify a decapitated human head. Studies as such have been thought to be more effective in identification because they incorporate gross morphological features as well as molecular genetics when presented to law enforcement agencies and the court [2].

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Superimposition and reconstruction in forensic facial identification: a survey

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Abstract

Forensic facial reconstruction is the reproduction of the lost or unknown facial features of an individual, for the purposes of recognition and identification. It is generally accepted that facial reconstruction can be divided into four categories: (1) replacing and repositioning damaged or distorted soft tissues onto a skull; (2) the use of photographic transparencies and drawings in an identikit-type system; (3) the technique of graphic, photographic or video superimposition; (4) plastic or three-dimensional reconstruction of a face over a skull, using modelling clay. This paper sets out to review work done on both superimposition and plastic reconstruction, however, the authors believe that only the latter category can correctly be termed facial reconstruction. The survey is divided according to work done through anthropological evaluation of the skull, clinical examination and dissection of the soft tissues, as well as methods of measuring soft tissue thicknesses using tissue puncture, ultrasound, cephalometric radiography and magnetic resonance imaging. In addition, a method of the combined use of ultrasound and radiography to collect a wider range of facial soft tissue depths and a method of producing skull and face profiles are outlined.

Keywords: Forensic; Reconstruction; Superimposition; Identification cephalometrics; Anthropometrics

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FEATURE ARTICLE

Anatomical Appraisal of the Skulls and Teeth Associated With the Family of Tsar Nicolay Romanov†

LEV L. KOLESNIKOV,* GURGEN A. PASHINYAN, AND SERGEY S. ABRAMOV

This article describes the identification of skeletal remains attributed to the family of Tsar Nicolay Romanov and other persons buried together at a site near present-day Ekaterinburg, Russia. Detailed descriptions are given regarding the objective methods of craniofacial and odontological identification that were used. Employing computer-assisted photographic superimposition techniques and statistical analysis of morphologic and other characteristics of the specimens, this study identifies with a high likelihood of certainty the remains of the Tsar, his wife, three of his four daughters, and four household assistants. Very strong evidence is presented that the Tsar's daughter Anastasia was killed in 1918. This study demonstrates the effectiveness of the methods and trustworthiness of the results, as well as the prospects of future application of the methods for the identification of skeletonized human remains. ***Anat Rec (New Anat) 265:15–32, 2001.*** **© 2001 Wiley-Liss, Inc.**

KEY WORDS: forensics; craniofacial identification; odontological identification; superimposition; skeleton; skull; teeth; Romanov, Tsar Nicolay; Romanova, Anastasia; Russia

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Dr. Kolesnikov is a Corresponding Member of the Russian Academy of Medical Science; Professor and Head of the Department of Anatomy, Moscow State Medical Stomatological University; Meritorious Science Worker, Higher Institutes of Learning, Federation of Russia; and President of the All-Russian Scientific Society of Anatomists, Histologists, and Embryologists. Dr. Pashinyan is Professor and Head of the Department of Forensic Medicine, Moscow State Medical Stomatological University, and Meritorious Science Worker, Federation of Russia. Dr. Abramov is Head of the Department of Forensic Medical Examination at the Federation Center and Meritorious Doctor of Medicine of the Russian Federation.
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The circumstances of the tragic death of the family of the last Russian Tsar Nicolay Romanov were, until recently, one of the most mysterious pages of Russian history. The collapse of the Communist regime in Russia during the last decade of the 20th Century has brought many of the facts surrounding this event to light. A brief account of the historical record follows, based upon Radzinsky (1992).

The collapse of the Communist regime in Russia during the last decade of the 20th Century has brought many of the facts surrounding this event to light.

Having abdicated March 2, 1917, Nicolay Romanov and his family were kept under house-arrest from March 9th. The Provisional Government, headed by A. Kerensky, sent the family, accompanied by servants and guards, to Tobolsk, a Siberian town on the eastern foothills of the Ural Mountains. When the Bolsheviks came to power, the new leaders, fearing that adherents of the dethroned Tsar would make efforts to free him, decided to send the family farther up the mountains; to the town of Ekaterinburg (known later as Sverdlovsk), capital of the Ural Soviet.

By the end of May 1918, the family was settled in a house of Nicolay Ipatiev, a local engineer. The much reduced household consisted, at the end, of the immediate members of the Tsar's family (age in parentheses): Tsar Nicolay II (50) and his wife Alexandra (47); their children Olga (22), Tatiana (21), Maria (19), Anastasia (17) Alexey (13); and four retainers: E. Botkin, a family doctor (61); A. Demidova, a house maid (20); I. Kharitonov, a cook (48); and A. Trupp, a valet (62). During the night between the 16th and the 17th of July, 1918, the Tsar, his family, and their retainers were killed.

According to witnesses, the execution was particularly violent. The victims were shot at close range, bayoneted, and bludgeoned with ri-

REVIEW ARTICLE

Forensic Odontology: The New Dimension in Dental Analysis

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ABSTRACT

Forensic Odontology a branch of Forensic sciences uses the skill of the dentist in personal identification during mass calamities, sexual assault and child abuse to name a few. This branch not stranger to many has been growing tenfold in its potential and its ability to bring the forlorn to justice where a dental remains is the only available evidence. It's role and importance in the judiciary is fast growing and hence in depth knowledge in this field seems more than justified. (*Int J Biomed Sci* 2017; 13 (1): 1-5**)**

Keywords: Forensic odontology; DNA Analysis; Bite Marks

INTRODUCTION

Forensic odontology is proper handling, examination, and evaluation of dental evidence, which will be presented in the interest of justice. The evidence that may be derived from the teeth, the age (in children) and identification of the person to whom the teeth may belong. Knowledge of forensic dentist requires encompassing of number of disciplines, since the dental records obtained can identify an individual or afford the information needed by the authorities to establish identification of the case (1).

Keiser-Neilson defined forensic dentistry as "that branch of forensic dentistry that in the interest of justice deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings (2)".

This article will give you a collective review on the evolution, various methods and applications of forensic odontology, which plays a major role in keeping the dental records accurately, and providing required information, which will help the legal authorities to recognize negligence, malpractice, fraud or abuse and identification of unknown individuals.

HISTORICAL BACKGROUND

66 AD: Well-documented evidence to the use of teeth for identification began AD with Agrippina and Lollia Pauline case. It was the first use of dental identification where there is a record.

1193: The first forensic identification in India started in were Jai Chand, a great Indian monarchy was destroyed by Muhammad's army and Jai Chand, Raja of Kanauji was murdered and he was identified by his false teeth.

1758: Peter Halket was killed in during French and Indian wars in a battle near Fort Duquesne. Halket son identified his father's skeleton by an artificial tooth.

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Identificación humana mediante superposición de imágenes. Una propuesta metodológica.

Human identification by superimposition of images. A methodological proposal.

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RESUMEN

Se presenta un nuevo método para la identificación humana por medio de análisis de imágenes y superposición fotográfica. Se discuten las ventajas que aporta la incorporación de imágenes tridimensionales del cráneo, ya que, por un lado, facilitan la superposición y por otro, eliminan errores de escalado al estar el modelo 3D a tamaño real. Este trabajo se ha desarrollado por un equipo interdisciplinar y su objetivo fundamental es proporcionar una herramienta semiautomática de identificación humana, basada en el reconocimiento craneofacial.

Palabras clave: Identificación humana, Superposición de imágenes, Análisis tridimensional.

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ABSTRACT

We present a new method for human identification by analysis of images and photographic superimposition. We discuss the advantages of including skull three-dimensional images, that provide the overlap and eliminate errors when scaling the 3D model in real size. This work was developed by an interdisciplinary team and its goal is to provide a tool for semi-automatic human identification, based on the craniofacial recognition.

Key words: Human identification, photographic superimposition, three-dimensional analysis.

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Suplemento

Superposición de fotografía digital de imágenes esqueléticas y dentales para la identificación forense.

Sara Angélica Vilchis Rodríguez, Dr. José Garza Garza, MSC, DSc, Dra. Ana Fabiola Rodríguez Sepúlveda.

Centro de Investigación en Ortodoncia y Ortopedia Maxilar.

Introducción:
Científicos forenses han desarrollado varias metodologías para la comparación de imágenes de personas desaparecidas con restos humanos desconocidos con el fin de probar su identidad.

Entre estos métodos, se ha utilizado la superposición de fotografías faciales sobre restos esqueléticos craneofaciales para validar la concordancia de características morfológicas durante el proceso de identificación. Entre estas metodologías de comparación gráfica se evaluó un análisis forense fotográfico digital basado en la comparación de las estructuras dentales mostradas en fotografías de personas desaparecidas en las cuales se muestran las piezas dentarias, con fotografías de especímenes de cráneo no identificados que muestran las estructuras dentales en una relación espacial similar.

Objetivos:
- Comparar y evaluar un análisis forense fotográfico digital basado en la comparación de estructuras dentales en fotografías sonrientes de personas desaparecidas.
- Definir con exactitud el coeficiente o factor de ampliación de la fotografía.
- Definir la metodología para establecer las comparaciones de las estructuras óseas y dentales con las estructuras morfológicas de los restos encontrados.

Metodología y material:
Para la fase de recolección de información, se utilizaron los siguientes datos: Edad, género y determinación de la raza: los restos se analizan para determinar la edad, el género y la raza.

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CASE REPORT

ANTHROPOLOGY; GENERAL

James A. Bailey,[1] *Ph.D.; G. B. Brogdon,*[2] *M.D.; and Brandon Nichols,*[2] *M.D.*

Use of Craniofacial Superimposition in Historic Investigation*

ABSTRACT: A skeleton discovered in Grand Forks, North Dakota was purported to belong to Clelland "Clell" Miller, a James-Younger gang member, who was killed during the Northfield Bank robbery on September 7, 1876. A 3-D image from a computer tomography (CT) scan of the skull was obtained, and a craniofacial superimposition was conducted to determine if the skull could belong to Miller. The superimposition method used in this case was to overlay the CT image of the skull onto Miller's postmortem photograph. In addition to the craniofacial superimposition, the images were juxtaposed to compare similarities or differences in facial morphology between the skull and photograph. Superimposition methods can be used to exclude identifications; however, they should not be used as a conclusive method for identification. In this case, there were sufficient similarities between the skull and Miller's photograph; therefore, the skull could not be eliminated as possibly being that of Miller.

KEYWORDS: forensic science, craniofacial superimposition, computer tomography, James-Younger gang, Northfield bank robbery, Clelland Miller, facial morphology

Craniofacial superimposition is the process of overlaying an image of an unidentified skull with an image of a person to determine if the facial morphology is congruent to the bony structure of the skull. The image of the skull can be a tracing on acetate, photograph, radiograph, video image, laser scanned image or digital image from a CT scan. The image of the person is usually from a family photograph (1–3). In some cases, craniofacial superimpositions can provide circumstantial evidence of identification or the skull can be excluded as matching the photograph (4).

In 2010, a skeleton was discovered in Grand Forks, North Dakota and alleged to be Clelland Miller, one of the James-Younger gang members killed in Northfield, Minnesota during the Sept. 7, 1876 First National Bank raid. The skeleton was obtained by a Grand Forks citizen in the mid-1980s when the Independent Order of Odd Fellows (IOOF) in Grand Forks disbanded and liquidated its property. When Dr. Henry Mason Wheeler retired in 1923, he allegedly donated the skeleton to the IOOF. According to the anonymous owner, the donation to the IOOF is based on information from Archie Nordeen and Peter Nickle who also later assisted in disposing of the property in Mae Wheeler's estate.

The primary reasons suggesting the skeleton may be Miller's are that Wheeler, who was a medical student in 1876, mortally wounded Miller during the bank raid and he acquired the cadaver for his medical studies (5–8). Miller's first burial was in the "Potter's Field" Section of Northfield Cemetery. However, Wheeler directed two medical school classmates to disinter the bodies of Miller and William Stiles aka William Chadwell and ship them to the University of Michigan Medical School where the bodies were to be used in an anatomy class (9–11). When Miller's family learned Miller's body was transported to Michigan, the family sent Clell's brother and a Missouri attorney to retrieve the body. A body with a damaged head was returned to Kearney, Missouri where the family had a proper second burial for Miller in Muddy Fork Cemetery (12–15). Whether Wheeler returned Miller's body or the body of another cadaver for burial is unknown. However, according to correspondence dated June 2, 1937 from Clarence E. Persons to Dr. Edwin C. Goodard, president of the University of Michigan emeritus club, Wheeler kept Miller's corpse. When Wheeler completed his medical studies, he began a practice first in Northfield, then in Grand Forks, and it was also reported that Wheeler sometimes displayed Miller's skeleton in his office (16–19).

Material and Methods

The putative Miller skull was scanned using thin axial CT sections (*c.* 0.6 mm). CT viewer software was then used to generate a 3-D image of the skull. The viewer software was used to adjust the image size as well as the position of the skull for comparisons. The skull was positioned in the same approximate position as Miller's head in a known postmortem photograph. The selected image orientation was then exported to a .tiff format file. A copy of Miller's photograph was converted to a digital file in the .tiff format using a flatbed scanner. The two acquired digital images were saved in a photograph folder to be subsequently used for comparison.

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Cranio-facial morphanalysis: a new method for enhancing reliability while identifying skulls by photo superimposition

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Abstract

Skull–photograph superimposition continues to be the most prevalent method employed for identifying a skull recovered in a criminal case as that belonging to a putative victim whose face photograph is available. The reliability of identification achieved has been shown to be 91%, indicating the possibility of a skull mismatching with a face photograph belonging to a person other than the actual deceased. This lack of reliability dampens the confidence of the expert and in turn confounds the mind of the judge. It has been shown that the variations in the shape of the facial organs are influenced by the corresponding variations in the skeletal elements of the facial skull. ''Cranio-facial morphanalysis'', a new anthroposcopic method proposed here for evaluating the shape correlations between a skull and a face photograph, when applied conjointly with skull–photograph superimposition is shown to increase the reliability in forensic skull identification.

Keywords: Skull–photo superimposition; Facial reconstruction guidelines; Cranio-facial morphanalysis; Enhancing reliability in skull identification

1. Introduction

Forensic anthropologists are constantly striving towards identifying skulls recovered in criminal cases as those belonging to missing individuals. Antemortem dental records [1,2] and radiographs of skull revealing bony traits [3–6] have been shown to indicate definite identification of skulls, although the availability of such records is relatively rare. Skull–photograph superimposition is the most prevalent method by which unknown skulls are being identified, since a photograph of the suspected dead person can be easily obtained from the victim's family. However, it has been shown that identification of skull by photo superimposition is not wholly reliable [7–12]. The correspondence of the shape between the fleshy facial organs and the underlying bony elements of the skull has been investigated to provide guidelines for facial reconstruction purposes [12–26]. The success in obtaining facial models from the skulls reflecting the exact likeness of the faces that existed has been shown to be difficult [18,22], although strikingly similar reconstructions have been made [16,22,23,27–29]. It is proposed that the collateral evaluation of the shape correspondence between the facial organs seen in a face photograph and their bony

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FOCUS

A cooperative coevolutionary approach dealing with the skull–face overlay uncertainty in forensic identification by craniofacial superimposition

O. Ibáñez · O. Cordón · S. Damas

Published online: 12 October 2011

Abstract Craniofacial superimposition is a forensic process where photographs or video shots of a missing person are compared with the skull that is found. By projecting both photographs on top of each other (or, even better, matching a scanned three-dimensional skull model against the face photo/video shot), the forensic anthropologist can try to establish whether that is the same person. The whole process is influenced by inherent uncertainty mainly because two objects of different nature (a skull and a face) are involved. In previous work, we categorized the different sources of uncertainty and introduced the use of imprecise landmarks to tackle most of them. In this paper, we propose a novel approach, a cooperative coevolutionary algorithm, to deal with the use of imprecise cephalometric landmarks in the skull–face overlay process, the main task in craniofacial superimposition. Following this approach we are able to look for both the best projection parameters and the best landmark locations at the same time. Coevolutionary skull–face overlay results are compared with our previous fuzzy-evolutionary automatic method. Six skull–face overlay problem instances corresponding to three real-world cases solved by the Physical Anthropology Lab at the University of Granada (Spain) are considered. Promising results have been achieved, dramatically reducing the run time while improving the accuracy and robustness.

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Keywords Forensic identification · Craniofacial superimposition · skull–face overlay · Fuzzy landmarks · Fuzzy distances · Evolutionary algorithms · CMA-ES · Coevolutionary algorithm · Genetic fuzzy systems

1 Introduction

Craniofacial superimposition (CS) (Krogman and Iscan 1986; Iscan 1993; Stephan 2009) is a forensic process where photographs or video shots of a missing person are compared with the skull that is found. By projecting both photographs on top of each other (or, even better, matching a three-dimensional skull model obtained scanning an unidentified human skull against the face photo/series of video shots), the forensic anthropologist can try to establish whether that is the same person. This skull–face overlay (SFO) process is usually done by bringing to matching some corresponding anthropometrical landmarks on the skull and the face.

SFO is known to be one of the most time-consuming tasks for the forensic experts (it takes several hours in many real-world situations) (Fenton et al. 2008). In addition, there is no systematic methodology for CS but every expert usually applies a particular process. Hence, there is a strong interest in designing automatic methods to support the forensic anthropologist to put it into effect (Ubelaker 2000).

In particular, the design of computer-aided CS methods has experienced a boom over the past 20 years (Damas et al. 2011). The most recent ones consider the use of laser range scanners to achieve a digital model of the human skull found (see Fig. 1) by means of a manual (Hee-Kyung et al. 2006) or automatic 3D reconstruction procedure (Santamaría et al. 2007, 2009a, 2010), as it is the case in the current contribution.

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Skull-Photo Superimposition and Border Deaths: Identification Through Exclusion and the Failure to Exclude*

ABSTRACT: We report on the application of video skull-photo superimposition as an identification method in a case from Ajo, Arizona in which five individuals died after crossing into southern Arizona from Mexico. Initial analyses at the Pima County Forensic Science Center in Tucson, Arizona determined that the disarticulated skeletal remains represented two adult Hispanic males and three adult Hispanic females. Based on biological profiles, both the males and one of the females were tentatively identified and assigned names. The other two females were too similar in age and height, making skeletal separation and identification difficult. As a result, the Michigan State University Forensic Anthropology Laboratory assisted in the identification efforts by performing video skull-photo superimposition on the two unknown females. The skulls were compared to a photograph reported to be one of the missing females. By evaluating facial proportionality and by comparing a number of morphological features of the face and skulls, one skull was excluded as a possible match and one skull was not excluded as a match to the antemortem photo. Because this case was presumed to be a closed disaster, the exclusion of one skull and the failure to exclude the other represented circumstantial identifications.

KEYWORDS: forensic science, forensic anthropology, identification, skull-photo superimposition, border deaths

Over the last decade, there has been a dramatic increase in the number of deaths among illegal border crossers trying to enter the United States along the Mexican border (1). Many of the individuals in these cases do not have antemortem X-ray or fingerprint records, making identification extremely challenging or impossible. As a result, when identifications in border death cases are made, they are often of the circumstantial variety. Typically, these circumstantial identifications are established through consistencies between antemortem and postmortem records, such as scars, dental features, tattoos, and other healed traumata (2). Skull-photo superimposition can also be a very useful identification technique in border deaths in the event that an antemortem photograph can be located. Identifications in such cases can be the result of either the exclusion of the skull as a match to the photograph or the failure to exclude the skull as a match to the photo.

Case Report

In February 2003, commingled human bones and personal effects were discovered by a hiker in a remote desert area near the southern Arizona town of Ajo. The Pima County Sheriff's Department responded and led a search team that included rangers from the Bureau of Land Management. The scene, located on the lower slope of a mountain, was rocky with sparse desert vegetation consisting mainly of mesquite and palo verde trees, ocotillo, and various forms of cacti. The search took place over a 2-day period and resulted in the recovery of five human skulls, numerous human postcranial skeletal elements, five backpacks, four personal identification cards, and clothing, all scattered over a 50–100 yard radius.

Using the evidence collected at the scene, investigators at the Forensic Science Center in Tucson, Arizona and the Pima County Sheriff's Office worked with the Consulate of the Republic of Mexico in the attempt to identify the deceased. Through these multi-agency cooperative efforts, the names of the five missing persons were established. Because of the level of certainty of this list of names, the situation was considered a closed disaster. A closed disaster is one where the names of victims are known, such as a flight manifest that lists all passengers and crew.

The five individuals believed to be traveling together in this case are listed as follows: Felipe V., 33 years old; Ricardo T., 42 years old; Reyna S., 32 years old; Elia R., 38 years old; and Amalia L., 22 years old.

The commingled skeletonized human remains were analyzed by forensic anthropologist Walter Birkby, Ph.D., at the Pima County Forensic Science Center in Tucson, Arizona. According to Dr. Birk-by, the remains represented two adult Hispanic males and three adult Hispanic females. The biological profiles he generated from the skeletal material are as follows:

Male #1: 30–45 years old, Hispanic, 5′4′–5′7′ tall.
Male #2: 35–50 years old, Hispanic, 5′3′–5′6′ tall.
Female #1: 30–40 years old, Hispanic, 5′2′–5′5′ tall.
Female #2: 30–40 years old, Hispanic, 5′1′–5′4′ tall.
Female #3: 20–25 years old, Hispanic, 4′6′–4′9′ tall.

Males #1 and #2 were identified through DNA analysis. In addition, it was possible to segregate the remains of Female #3 because of the comparatively young skeletal age (20–25 years). These remains were presumed to represent the missing woman Amalia L., who was 22 years old at the time of her disappearance. However, it was not possible to segregate Females #1 and #2 because of the similar skeletal age ranges (30–40 years) and stature ranges

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TECHNICAL NOTE

Ground truth data generation for skull–face overlay

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Abstract Objective and unbiased validation studies over a significant number of cases are required to get a more solid picture on craniofacial superimposition reliability. It will not be possible to compare the performance of existing and upcoming methods for craniofacial superimposition without a common forensic database available for the research community. Skull–face overlay is a key task within craniofacial superimposition that has a direct influence on the subsequent task devoted to evaluate the skull–face relationships. In this work, we present the procedure to create for the first time such a dataset. We have also created a database with 19 skull–face overlay cases for which we are trying to overcome legal issues that allow us to make it public. The quantitative analysis made in the segmentation and registration stages, together with the visual assessment of the 19 face-to-face overlays, allows us to conclude that the results can be considered as a gold standard. With such a ground truth dataset, a new horizon is opened for the development of new automatic methods whose performance could be now objectively measured and compared against previous and future proposals. Additionally, other uses are expected to be explored to better understand the visual evaluation process of craniofacial relationships in craniofacial identification. It could be very useful also as a starting point for further studies on the prediction of the resulting facial morphology after corrective or reconstructive interventionism in maxillofacial surgery.

Keywords Forensic anthropology · Craniofacial superimposition · Computer-aided craniofacial superimposition · Skull–face overlay · Ground truth · Craniofacial relationships

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Introduction

Anthropologists have focused their attention on determining the identity of a missing person when skeletal information becomes the last resort for the forensic assessment [1, 2]. Craniofacial superimposition (CFS) [3], one of the approaches in craniofacial identification [4, 5], involves the superimposition of a skull (or a skull model) with a number of antemortem images of an individual and the analysis of their morphological correspondence.

Regardless of the technological means considered, we distinguished three different stages for the whole CFS process in [6]: (i) the first stage involves the acquisition and processing of the skull (or skull 3D model) and the antemortem facial images together with the craniometric and facial landmark location, (ii) the second stage is the skull–face overlay (SFO), which focuses on achieving the best possible superimposition of the skull and a single antemortem image of the missing person. This process is repeated for each available photograph, obtaining different overlays. SFO thus corresponds to what traditionally has been known as the adjustment of the skull size and its orientation with respect to the facial photograph [3, 7], and (iii) the third stage accomplishes the decision-making. Based on the superimpositions achieved in the latter SFO stage, the degree of support of being the same

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Identification of Skulls by Video Superimposition

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REFERENCE: Iten, P. X., "Identification of Skulls by Video Superimposition," *Journal of Forensic Sciences*, JFSCA, Vol. 32, No. 1, Jan. 1987, pp. 173-188.

ABSTRACT: A method of matching skulls with photographic portraits or impressions of the face in clay by video superimposition is described. Two different practical cases are presented. The first one deals with the identification of a skull of a six-year-old girl, the second with the identification of the skull of the famous Swiss Pedagogue Johann Heinrich Pestalozzi, who died about 160 years ago. The advantages and versatility of this method are shown; also the setup of the equipment and the working technique.

KEYWORDS: physical anthropology, human identification, musculoskeletal system, superimposition, skulls, video, impression of the face in clay, Johann Heinrich Pestalozzi

Equipment and Working Technique

The most widely known use of the video superimposition method to date is connected with the identification of skulls [*1,2*]. Over a period of about eight years we have found the following equipment and working technique to be the best.

The apparatus should consist of two video tubes, 1 and 2 (advantageously CCD cameras), electronic and mixer units, and three monitors (Fig. 1). The couple of video tubes (including optical lenses) must be adjusted by video test pictures. The skull in question is first taken with Tube 1 and reproduced on Monitor 1. For comparison purposes, a photograph of the missing person is then reproduced with Tube 2 on Monitor 2. The picture-mixing unit not only allows an infinitely variable mixing of the two pictures, but also the creation of horizontal and vertical sections at any desired point. These sections and the mixed pictures are then apprised on Monitor 3. For registration purposes, essential investigation results can be recorded on tape or photographed directly from the monitor with a camera.

The first step in the investigation is to determine the correct height and location for Camera 1 to stand. Thanks to its versatility, the video superimposition method presents enormous advantages over the former photographic superimposition processes [*3-5*]. The correct location has, of necessity, to coincide with that for the taking of comparison photographs and is defined by a number of variable parameters such as distance between camera and object, camera height, and height and orientation of the skull.

The answer to this problem lies in the two-dimensional comparison picture since, as already known, according to optical and perspective laws, *three-dimensional* objects, for instance a skull, appear differently on *two-dimensional* photographs, depending on the direction and distance involved when pictures are being taken.

To achieve an as exact as possible determination of the parameters, we developed various techniques which would facilitate the practical work involved. For instance, one can obtain

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Past, present, and future of craniofacial superimposition: Literature and international surveys

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ABSTRACT

In this manuscript, the past, present and future of the identification of human remains based on craniofacial superimposition is reviewed. An analysis of the different technological approaches developed over time is offered in conjunction with a new classification based on the technology implemented throughout the diverse phases of the process. The state of the art of the technique, in the academic and forensic realms, is reflected in an extensive international survey that includes over one hundred experts worldwide.

The results of the survey indicate the current relative importance of the technique, despite of its controversial nature within the scientific community. Finally, the future challenges to be faced to justify the use of this technique for either profiling, exclusion or identification purposes are discussed.

Contents

1. Introduction

The main focus in forensic anthropology lies on the determination of the identity of human remains when skeletal information becomes the last resort for forensic assessment [1,2]. Craniofacial

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CRANIOFACIAL IDENTIFICATION BY COMPUTER-MEDIATED SUPERIMPOSITION

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ABSTRACT

Mass disasters are associated with a large number of fatalities, with victims being visually unidentifiable in most cases. Dental identification, although being an important and valuable identification method, is subject to the availability and quality of antemortem and postmortem dental records. This paper presents a simple-to-use method of human identification using an antemortem photograph showing anterior teeth with superimposition onto a postmortem image using specific features of Adobe® Photoshop®.* We present cases and discuss the benefits and difficulties of this method.

(J Forensic Odontostomatol 2006;24:47-52)

Key words: superimposition, identification, Adobe Photoshop, victim; tsunami, disaster

INTRODUCTION

The identity of the dead is important for well-appreciated reasons. In most cases a family member or acquaintance is able to identify the deceased visually, but this method is sometimes inapplicable if the deceased has lost facial features. Cases of incineration, decomposition or skeletalization necessitate the use of a scientific identification method. The use of dental characteristics is an identification method that has significant utility due to its accuracy, cost and time effectiveness by comparison with other identification methods. Postmortem dental material can sustain harsh circumstances, such as fire and petrifaction, and still retain utility as an identification method. However the greatest problem is often the lack of sufficiently detailed antemortem records to allow for a meaningful comparison. If these limitations occur other methods of identification need to be approached and photographic superimposition is one such method.

In this paper, we present cases which were identified using Adobe® Photoshop® version 7*. We discuss the technique with emphasis on its value as a supplementary identification method in mass disasters where forensic odontologists might be challenged with victims whose antemortem dental records are inadequate or are absent.

Case one

A middle aged male died in the Indian Ocean tsunami disaster. His body was decomposed and was visually unidentifiable at the time of postmortem examination. Dental examination revealed extensive restorative work and missing upper lateral incisor teeth. More than seven months after his death, the dental reconciliation team was able to find a possible antemortem dental record which showed missing upper lateral incisor teeth and only one restoration on the upper right second molar. Both features were consistent with the postmortem findings, but were considered insufficient for identification to be established.

Considering that the anomaly of missing upper lateral incisors is uncommon, an attempt to perform superimposition was undertaken. Several antemortem portraits showing anterior teeth were obtained from the next of kin. One of these showed upper anterior teeth in reasonable resolution. The antemortem photograph was scanned at 600 dpi and a series of postmortem photographs was taken from different angles by using a three-step ladder (five horizontal positions, approximately thirty centimeters apart, and three vertical positions from each horizontal position, approximately fifteen centimeters apart) with a digital single-lens reflex camera.** Postmortem images with the closest viewing angle to that of the antemortem portrait were selected; then superimposition, using Adobe® Photoshop®, was performed and successfully resulted in a consistent dental and craniofacial match (Fig.1). DNA analysis

*Adobe Systems Incorporated, California USA 2002

**Canon EOS 300D, Canon Inc. Tokyo, Japan

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Radiography Superimposition in Personal Identification - A Case Study Involving Surgical Implants

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Abstract

Till date, the identity of decomposed corpse is a challenging task in all Forensic Laboratories.DNA typing is the primary technique for personal identification. Using ante-mortem and post-mortem DNA profiles in personal identification is impossible in South Indian population due to non-availability of DNA profile for the existing population. Personal identity of the deceased becomes critical in instances like the absence of parents and children for DNA profile comparison. Skull-photograph superimposition is another technique for personal identification in Forensic Science Laboratories. One-third of the cases received for identification through DNA profiles failed with some technical inabilities. Though superimposition technique is easily available and most pioneering, only a probable opinion could be arrived from it. But the court of law accepts only the conclusive identity, the DNA profiles give. When ante-mortem dental records or radiographs are received for superimposition, the conclusive identity will be achieved. In this case of personal identity of a skull, DNA profiles for comparison could not be obtained as the deceased had no parents and children, the skull-photograph superimposition offered only a probable opinion, but the superimposition of the photographs of ante-mortem and post-mortem radiographs of the surgical implant (stainless steel orthopedic fixation device) of the suspected deceased rendered conclusive identity.

Keywords: Personal identification; DNA profile; Skull-photo Superimposition; Post-mortem and ante-mortem dental records; Stainless steel orthopedic fixation device; conclusive identity.

Introduction

The DNA profiling and Skull-photograph superimposition are the techniques adopted in Forensic Science Laboratories for personal identification. The first use of DNA testing in a forensic setting came in 1986 [1] and it is the 'Primary Identifier' at present in Forensic Laboratories as it gives conclusive identity.

The skull-photograph Superimposition is the most prevalent method used for identification of unidentified skulls recovered from the scene of crime [2]. The work of Glaister and Brash [3] in Mrs.Ruxton's case had given a good start for superimposition for establishing individual identity. A variety of techniques were applied in identification of skulls using skull-photograph superimposition [4-16] and attempts are still going on to reduce the ambiguities due to soft tissue thickness in Cranio-Facial matching of skull – photograph superimposition [17]. The facial soft tissue thickness was studied by magnetic resonance imaging (MRI) for 300 individuals of northwest Indian adults and the data was published with the comparative study with some other races. This helps the forensic experts in reconstructing the face from the skull for identification purpose [18]. Comparison of ante-mortem and post-mortem radiograph is a commonly used technique for identification in Forensic Anthropology [19,20]. Superimposed comparison of radiographs proved useful when the areas of interest were small or hard to visualize with side by side or over lay techniques [21]. Skull-Photo Superimposition can also be a very useful identification technique in border deaths in the event that ante-mortem photographs can be located [22].

Though the superimposition technique is the easily available and is most pioneering identifier for personal identification, a probable opinion could only be arrived. Cautions have been given by many researchers regarding 'false match' or 'mismatch' in skull – photograph superimposition technique [8,23-26]. Some researchers established the anatomical relationships other than the metrically correlating characters between the organs of the skull and the face [27-32]. Since the persons belonging to closely-inbreeding populations are known to share a striking similarity in their facial features only a probable opinion could be offered by this technique. The cranio-facial morphanalysis (evaluating the shape correlations between a skull and the face) is suggested as a conjoint application for skull-photograph superimposition to enhance the reliability of identification and to increase the confidence of the analyzing expert [2,31].

When ante-mortem dental records or radiographs of a suspected deceased are received along with the skull for identification, the definite identity could be achieved [33-38]. But the availability of such dental records and radiographs are very rare in Indian population. In few instances, the dental pattern superimposition is used for definite inclusion and exclusion.

Problems during Skull-photograph Superimposition:

The following situations will reduce the level of confidence of the analyzing expert.

1) Non-availability of clear photograph.

2) The available hazy photograph does not reveal the facial features of the suspected deceased.

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Personal identification through digital photo superimposition of dental profile: a pilot study

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KEYWORDS

Dental superimposition
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ABSTRACT

The usefulness of teeth for personal identification lies mainly in their vast individual variability, making them virtually unique for every subject. Odontological identification represents a reliable and important complement to forensic inquiries, in particular in the event of unidentifiable human remains. However, this technique is based on the availability of ante-mortem records containing significant evidence. In the absence of dental records, the only available ante-mortem elements are often photographs. In the present study, dental profile photographs of selected smiling subjects were compared to the relevant plaster study models through digital image analysis. In order to ascertain the reliability of the technique, the comparison was carried out both in a homologous and heterologous manner with the Facecomp software. The results confirm the ability of Facecomp software to identify even the smallest variations in dental elements to reach a positive identification. The method is useful in forensic practice since a forensic inquiry may obtain plaster models from cadavers for comparison with photographs of missing people's anterior teeth.

INTRODUCTION

The usefulness of teeth for personal identification lies mainly in their vast individual variability, making them virtually unique for every subject.[1]

Therefore, dental identification represents a useful technique for personal identification based on ante-mortem records comparison (such as x-rays, plaster study models, palatine rugae and information contained in dental/medical records) with post-mortem records. However, obtaining adequate ante-mortem dental records is not always possible and this is particularly true in Italy where the number of illegal immigrants are on the rise. Indeed, in such cases, most of the available material is represented by photographs obtained from friends and acquaintances through which we attempt to identify an unidentified body. This can be achieved through the technique of photographic superimposition. Such a technique is even more reliable than craniofacial superimposition where the comparison is carried out between facial soft tissues and cranium skeletal structure.[2-6] With dental profile superimposition, the only skeletal elements, teeth are compared, even in a living subject.

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CASE REPORT

ODONTOLOGY

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Positive Dental Identification Using Tooth Anatomy and Digital Superimposition

ABSTRACT: Dental identification of unknown human remains continues to be a relevant and reliable adjunct to forensic investigations. The advent of genomic and mitochondrial DNA procedures has not displaced the practical use of dental and related osseous structures remaining after destructive incidents that can render human remains unrecognizable, severely burned, and fragmented. The ability to conclusively identify victims of accident and homicide is based on the availability of antemortem records containing substantial and unambiguous proof of dental and related osseous characteristics. This case report documents the use of digital comparative analysis of antemortem dental models and postmortem dentition, to determine a dental identification. Images of dental models were digitally analyzed using Adobe Photoshop™ software. Individual tooth anatomy was compared between the antemortem and postmortem images. Digital superimposition techniques were also used for the comparison. With the absence of antemortem radiographs, this method proved useful to reach a positive identification in this case.

KEYWORDS: forensic science, forensic odontology, human identification, permanent molars, dental anatomy, digital superimposition, Adobe Photoshop™

A fiery automobile crash took the lives of five young foreign exchange students in early 2009. They were from various European countries and were heavily burned due to the intense fire that occurred after the crash. Recent dental radiographs and written clinical records were eventually received and were sufficient to identify four individuals. It was impossible for the coroner investigators to acquire antemortem dental radiographic records of the fifth victim whose identity could only be presumed by exclusion of the other deceased occupants of the car. This presumed victim was a 25-year-old woman. The only antemortem evidence for this victim consisted of upper and lower dental casts with the patient's name and the date, June 19, 1996, written on each model. These casts were taken approximately 13 years prior to the accident. This correlates to the patient being 12 years old at the time of this dental treatment.

Methods

The 13-year-old dental models indicated the 12-year-old patient was in the late mixed dentition stage where permanent adult anterior teeth (#'s 7, 8, 9, 10, 22, 23, 24, 25, 26, and 27) and three permanent posterior teeth (#'s 3, 14, and 19) were present and fully erupted. Four deciduous posterior teeth were still present (A, J, K, and T). The three permanent posterior teeth were used for comparison purposes with the adult dentition of the 25-year-old victim. Fig. 1 shows the upper and lower antemortem models.

The postmortem dental remains were replicated in yellow dental stone obtained from Jeltrate™ Plus alginate impression material (DENTSPLY Caulk, West Clarke Avenue, Milford, DE). Fig. 2 shows the upper and lower postmortem models.

The fully erupted permanent anterior teeth were not used for the comparison due to their lack of anatomical features. The anatomical features of three permanent molars (#'s 3, 14, and 19) were visually and digitally examined using Adobe Photoshop™ image editing software (Adobe Systems Incorporated, San Jose, CA) and methods commonly used in forensic digital bite mark analysis (1).

Metric and nonmetric shape analyses were performed. Individual images of the three teeth were produced by digitally cropping these teeth out of the original antemortem and postmortem full arch images, which were photographed using a Canon EOS20D™ digital camera (Canon U.S.A., Inc., Lake Success, NY). This produced six images of the individual teeth used for comparison (antemortem and postmortem tooth #3, antemortem and postmortem tooth #14, and antemortem and postmortem tooth #19). These six images can be seen in Fig. 3.

Methods

The comparison method involves digitally outlining the features of the antemortem tooth and overlaying this pattern onto the postmortem image. The specific occlusal anatomy of both teeth was evaluated for consistent and inconsistent features under high magnification. The stellate-shaped mesial fossa and marginal ridge area of tooth #14 in both evidence samples were chosen due to its uncommon configuration of grooves and fissures. This area was selected within the antemortem image using

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TECHNICAL NOTE

Dental superimposition: a pilot study for standardising the method

D. De Angelis · C. Cattaneo · M. Grandi

Received: 10 October 2006 / Accepted: 20 August 2007 / Published online: 13 September 2007

Abstract Dental superimposition is becoming more and more important because of the increasing number of illegal immigrants (at least in Italy), with no clinical history, no personal effects or relatives useful for genetic comparison, whose friends and acquaintances can usually only produce photographs. Very few authors have been involved in devising and using this method. The goal of the present study is to establish whether it is possible, and under which conditions, to identify individuals by dental superimposition of teeth visible in an ante-mortem photograph and dental casts of an unidentified body, and to develop a protocol for the spatial orientation analysis of the dentition and qualitative and semi-quantitative analysis of superimpositions. A non-mathematical scoring system has been applied to each superimposition as a first step towards the optimisation of a cheap, quick, semi-quantitative method of identifying individuals when other more used methods are not applicable.

Keywords Forensic odontology · Identification · Dental superimposition

Introduction

Identification of cadavers, with all its moral and legal implications, must be pursued, for ethical and legal reasons with all means. Experts involved in identification are usually odontologists, geneticists and anthropologists. The role of forensic odontology is perhaps by far the most diverse because it involves comparing post-mortem dentition with various ante-mortem types of material: dental recorded information, dental casts, intra-oral X-rays, OPG, clinical pictures, palatal rugae, or even photographs (normal snapshots of smiling people). This last condition is perhaps the most difficult and consists of comparing the ante-mortem dentition (superior incisors and canines) visible in a picture of a smiling person, with the post-mortem dentition via superimposition. This method is becoming more and more important because of the increasing number of illegal immigrants in Italy, with no clinical history, particularly for the teeth, no relatives or personal effects useful for genetic comparison. Their friends and acquaintances can usually only produce photographs or videoclips of the missing person, hopefully smiling, useful for dental superimposition. This identification procedure could increase reliability of cranio-facial superimposition as hard tissues (teeth) are compared and superimposed to the same hard tissues while in cranio-facial superimposition hard tissues (skull) is compared and superimposed to different soft tissues (face of the presumed victim) [1–5]. Very few authors have been involved in devising and using this method. McKenna initially studied methods for enlarging photographs to life-size according to dental measurements and then published a method for orienting the cranium by trial and error. He then approached dental superimposition by studying only the occlusal margins of the dentition and stressed the peculiarity of each individual dentition [6–9]. However, no author has published a complete protocol, from spatial orientation of the head to qualitative and quantitative assessment of correspondence of two dentitions.

Craniofacial superimposition methods have been studied in greater detail; however, they rarely, apart from their use in spatial orientation, focus on a protocol for teeth [10–13].

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DENTAL ANOMALIES AND THEIR VALUE IN HUMAN IDENTIFICATION: A CASE REPORT

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ABSTRACT

Forensic odontology and anthropology provide valuable support with regard to human identification. In some cases, when soft tissue is destroyed, carbonized or absent for whatever reason, bones and teeth become the only source of information about the identity of the deceased. In human identification, anything different, such as variation from normality, becomes an important tool when trying to establish the identity of the deceased. This paper illustrates a positive identification case achieved by the diagnosis of an anomaly of tooth position, with confirmation using skull-photo superimposition. Even though forensic science presents modern techniques, in this particular case, the anomalous position of the canine played a key role on the identification, showing that the presence of a forensic dentist on the forensic team can be of great value.

(J Forensic Odontostomatol 2010;28:1:39-43)

Keywords: Forensic science, forensic dentistry, dental anomalies, human identification, skull-photo superimposition.

Running title: Dental anomalies and human identification

INTRODUCTION

Anthropologists and odontologists usually have a leading role in the forensic team when dental structures are the only source of information for the identification of human remains. The resistance of teeth and their supporting tissues, even to fire and decomposition, makes them extremely useful for identification purposes.[1-4] In cases of carbonization, advanced decomposition, or partial destruction, all attention turns to the analysis of bones and teeth, and forensic experts need support from the family of suspected victims, on providing clear and complete antemortem medical and/or dental records, to be compared with the remains.[5-9]

For the identification of human remains, anything that distinguishes one person from another, such as a tattoo, or a variation from normality, becomes very important to the forensic team, greatly assisting the identification process. This is the reason why literature shows cases of abnormality, asymmetry and pathology narrowing the search within missing persons files.[3,10] However, few authors discuss the forensic value of dental anomalies that are commonly missed by medical examiners. These variations, analyzed by dental examiners, can potentially lead to a positive identification.[2,3,6,7,11]

In the absence of antemortem information, the forensic team search for alternative sources of reference, such as photographs[12-14] and videotapes[15] for personal features that may be identifiable at the postmortem examination. One of the techniques used in these cases is the skull-photo superimposition. Identification by this method is based on the matching of the outline and positional relationships between anatomical points on the face, and their locations on the skull.[16-20]

This paper reports a recent positive identification case of a Brazilian girl, achieved by the discovery of an anomaly of tooth position and confirmed by skull-photo superimposition, showing the importance of the odontological analysis in this case, along with the anthropological evaluation of personal photographs for human identification.

FORENSIC ODONTOLOGY IDENTIFICATION USING SMILE PHOTOGRAPH ANALYSIS – CASE REPORTS

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ABSTRACT

The identification of unknown human by smile photographs that show specific characteristics of each individual has found wide acceptance all over the world. Therefore this paper shows this situation reporting different cases which smile photograph analysis were crucial to determine the positive identification of unidentified human bodies. All the cases were subjected to personal identification by photographs of smile including one adult male found in an advanced stage of decomposition, one adult female disappeared during an ecotourism trip, and one carbonized body of a male individual found in a forest region. During the autopsy the photographs of the smile were used by comparison of the ante and postmortem images gave accurate and useful information not only about dental state but also the anatomical features surrounding the upper and lower anterior dental arches. This method is not time-consuming and also has the advantage of allowing extraoral dental examination. It is also recommended when there is a need to provide quantitative data for a forensic identification based on these structures. **(J Forensic Odontontostomatol 2008;27:1:12-17)**

Keywords: human identification, smile photograph, forensic odontology

INTRODUCTION

The identification of human bodies that are carbonized, mutilated or skeletonized or in the process of decomposition, through the analysis of dental characteristics is a common task for the medical legal department[1]. Thus, it is necessary that experts seek from family members any type of odontologic documentation that contains diverse identification characters of the individual to be identified.

Among the documents most frequently used to help forensic odontology task are the dental records, patient records,[2] cast models,[3] intraoral photographs,[4] periapical radiographs,[5, 6] interproximal and panoramic radiographs[7] and postero-anterior skull radiographs.[8]

However, in certain cases, the victim being analyzed may not have clinical records showing relevant odontologic characteristics. Therefore, experts in the practice of human identification currently search for information from alternative sources, such as facial photographs,[9] video recording[10] or smile photographs[11] that show specific characteristics of each individual.

Considering the importance of searching for new parameters of human identification using odontologic characteristics, the aim of the present work was to point out, by means of three criminal investigation cases, the importance of the forensic odontology analysis of smile photographs in human identification.

CASE 1

A male subject showing compatible age with the transition between adolescent and adult, was found in an advanced stage of decomposition. During forensic odontology examination, it was noted that the individual had practically healthy-appearing remaining dental elements, where only the upper left central incisor (21*, FDI notation) was absent, with characteristics compatible of former dental loss while still alive. In this region, the alveolar process appeared to have undergone remodeling and part of the mesio-distal space was found to be partially preserved (Figs.1A,1B). The police investigation found that a male with anthropologic characteristics matching those of the recovered body had disappeared in the same region for a few days. In attempts of finding the missing person, family members

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MEPROCS framework for Craniofacial Superimposition: Validation study

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ABSTRACT

Craniofacial Superimposition (CFS) involves the process of overlaying a skull with a number of ante-mortem images of an individual and the analysis of their morphological correspondence. The lack of unified working protocols and the absence of commonly accepted standards, led to contradictory consensus regarding its reliability. One of the more important aims of 'New Methodologies and Protocols of Forensic Identification by Craniofacial Superimposition (MEPROCS)' project was to propose a common framework for CFS, what can be considered the first international standard in the field. The framework aimed to serve as a roadmap for avoiding particular assumptions that could bias the process. At the same time, it provides some empirical support to certain practices, technological means, and morphological criteria expected to facilitate the application of the CFS task and to improve its reliability. In order to confirm the utility and potential benefits of the framework use, there is a need to empirically evaluate it in CFS identification scenarios as close as possible to the reality. Thus, the purpose of this study is to validate the CFS framework developed. For that aim 12 participants were asked to report about a variable number of CFS following all the recommendations of the framework. The results are analysed and discussed according to the framework understanding and fulfilment, the participants' performance, and the correlation between expected decisions and those given by the participants. In view of the quantitative results and qualitative examination criteria we can conclude that those who follow the MEPROCS recommendations improve their performance.

1. Introduction

Within the various postmortem identification techniques, Craniofacial Superimposition (CFS) [1–3] is considered a controversial technique within the scientific community. The lack of unified working protocols among practitioners as well as the absence of commonly accepted standards in the application of the technique, led to contradictory arguments regarding CFS reliability [4–6]. However, there is a very frequent application of the technique in developing countries [7]. The high criminal rates and limited funds for identification are probably behind the mains reasons for applying CFS in such regions. On the contrary, there is a progressive reduction on the application of CFS in developed countries [2] due to the boom in the application of alternative, and more

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