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Forensic Dentistry: An Overview of the Human Identification's Techniques of this Dental Specialty

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Abstract

The dentist who graduates to work in a dental clinical practice, finds a new professional branch in Forensic Dentistry. This review article reports the different fields of Forensic Dentistry and shows the importance of this specialty. Furthermore, it presents a review of current literature on different oral methods of human identification (dental arch exams, palatal rugae, and tooth extractions for the posterior examination of the DNA of the dental pulp) that are responsibility of the forensic dentist. The dentist is the only one who has the proper skills to investigate forensic clues found in a cadaver. A vast knowledge is required of the dentist to work in this area, because of the many responsibilities.

Keywords: Forensic; Dentistry; Human; Identification

Introduction

The need for justice in resolving conflicts has created a need for experts, who are nothing more than specialists in their areas of expertise. Thus, dentistry has contributed in clarifying the facts in the interest of justice. Experts are appointed by competent authorities to clarify facts through expert evidence. They should possess not only expertise in their area but the legal concepts that involve the examination. An expert with the power to convict or acquit a person must be impartial and must refrain from inserting personal judgments into any documents. There are unofficial experts who are appointed by authorities to replace experts or officials. The experts *"ad hoc"* are appointed by a judge, regardless of whether government experts are available. And these experts carry out this assignment for the Government. In the civil courts, parties can recommend trusted professionals to monitor the work of experts without participating in criminal courts.

The objective of forensic dentistry is the research of psychic phenomena, physical, chemical, and biological agents that could affect or have already affected people, alive, dead or their bones and even fragments or traces, resulting in reversible or irreversible partial or total injuries [1,2].

The duties of forensic dentists are restricted to analysis, expertise, and evaluation of events related to the area of expertise. The practice areas of forensic dentistry are human identification; expertise civil court, criminal and labor law; administrative expertise; thanatology, forensic preparation of records, reports, opinions, reports and statements; trauma forensic ballistics, forensic expertise in trace correlates, liquids and stains from the buccal cavity; dental ethics; dentistry guidance for the profession; imaging studies for purposes dentistry.

The civil court can act in dentistry damages, arbitrarily, judicial professional fees, paternity exclusion, age estimate and evaluation of dental equipment. In the labor court he can act when the accident reaches the face, mouth or when there are diseases with oral manifestation. The administrative area conducts audits of health plans for both public and private institutions.

Here, we will study forensic work in the area of human identification through the examination of dental arches, palate rugoscopy, identification of anthropological interest in dentistry, the study of bite marks, and identification by DNA.

Inspection of dental arches

Teeth are unique; no two people have the same teeth. Knowledge of dental anatomy is very important; when examining a tooth, one must differentiate between deciduous and permanent teeth. Subsequently, he must determine the group in which the tooth belongs (incisors, canines, premolars, molars), and whether it is superior or inferior. He must identify the abnormal situation and implement a corresponding dental formula. Identification by teeth is important especially in cases of major disasters, in which often only the dental arches remain because of their resistance to high temperatures and bad weather. The expert must be prepared to work with the arches and teeth together and with each as individual elements, in which only one tooth is found. He must then be able to tell whether the element is of human origin, and the position in which it would be found.

Distrophy and dental anomalies: Are important, once those are the salient points and seconded in an arch, facilitating the personal identification of the perpetrator. It can occur by genetic disorder, childhood disease, fever and skin rash, gastrointestinal disorders, injuries, trauma etc.

Anomalies of volume may be coronary, and root total: The second type may be stunting (low volume) or gigantism (volume increase).

Anomalies of number: These can occur in both deciduous and permanent teeth and include conditions at which the patient has

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missing teeth as a result of their failure to develop such as anadontia (no teeth), oligodontia (decreased number of teeth), polidontia (increased number of teeth).

Shape anomalies: These include conoides (teeth with two cones juxtaposed by base), dilaceration, coalescence (concretion, fusion and germination), erosion (in pits, fissures and surfaces).

Anomalies of position: Direction: change in position of teeth according to the axis vertical, lateral, and anteroposterior. Location: can occur by extension, migration, or genesis.

Anomalies of eruption: These include early eruption, delayed eruption, early fall, inclusion, impactions, tertiary dentition, and teeth at birth.

Changes due to habits: Over the years, the individual may acquire certain habits that leave marks on his or her teeth. Consider a few: the grating of teeth, biting nails, geophagy (when one eats strange things such as sand), abrasive powder, smoking pipes, cigarette holders, darkening of the teeth by smoking, professional alterations. Among the latter, we have marks of apprehension objects, arsenic, bismuth, chromium, fluoride, lead etc.

Examination of the teeth: Even when there is no documentation for comparison, examination of the teeth can give clues about the victim's identification. Teeth can provide information such as the following:

Species: The study of the species only brings trouble when a part is found out of its tooth socket or isolated from the other teeth.The fundamental morphological feature that makes human teeth different from those of other species is that the crown and the root are in the same plane, appearing as segments of straight stems. The teeth of animals have a curved root, with great angulation. It is often necessary to use comparative zoology to clarify doubts.

Racial Group: The molars are the group that reveals racial characteristics (Table 1) Orthognathic races (whites or Caucasians): cusps palatinedistals are very small compared with the mesopalatines. The main groove is well marked. The second and third molars have further differentiated cusps.

Races with prognathism (black and brunette skin): the molar cusps palatinedistals show a good size. Lower molars, a posterior cusp differentiated. The index tooth used to establish differences between racial groups is the index of Flower:

Flower index values=(length between the straight edge of 1 pm mesial and distal border of the 3rd m) x100

Type	Dental Index=ID	Ethnic group
Microdont	<41.9	Caucasians
Mesodont	42.0a 43.9	Negroids, mongoloids
Megodont	>44.0	Australoids

Table 1: Flower index values.

	Male	Female
Central incisor	Most volumous	Least volumous
Relation between the diameter of ILS e o ICS	Major	Minor, more regular with each other
Chronology of the eruption	Later	More early

Table 2: Teeth differences between sexes.

Sex: It is apparent that the upper incisor teeth show greater sexual dimorphism between the sexes (Table 2).

Height: The method was perfected by the Argentinian Professor Carrea and is based on the fact that the diameter of the teeth is proportionate to the height of the individual.

The teeth are measured in millimeters, in the lower arch, of the mesiodistal diameters of the central incisor, canine and lateral (one side) and its sum is called the arc. The chord of the lower arch is measured in a straight line between the initial points (mesial edge of the central incisor) and final (distal border of the canine on the same side). So, the human height must be between these two measures. The height of a male will be closer to the maximum height; the height of the female will be closer to the minimum height.

Formulas for application:

Maximum Height=arc x 6 x 10 x 3.1416/2

Minimum height=cord x 6 x 10 x 3.1416/2

Age determination: It is known that there are three periods of human life: growth, stabilization, and aging. Methods have been sought to improve and develop techniques that use evolution and involution or organic processes for determining the age. Studies have shown that teeth provide the most accurate information around the age until 24 years, because they suffer less interference from malnutrition and systemic factors, thereby reducing the margin of error. The estimated age by examining the teeth, first, analyze all the present elements together, collecting data to characterize a phase of life of the person examined and then determine its age. The earlier the person, the closer it can get to a chronological age. After an individual acquires the third molars, age determination becomes less accurate because these are the last elements to eruption and, therefore, there is inadequate information to determine the dental development of the individual.

This type of examination is made directly or indirectly. It is made directly when conducted through clinical examination, which follows the eruptive sequence, general state of the teeth (dental caries, wear, tooth extraction, etc.). The indirect test is performed by X-rays, which is observed the clinical features and the degree of tooth mineralization, which is the most accurate indicator of age. Several studies have shown that females have earlier tooth eruption than males, and the mandible teeth erupt earlier than the maxilla.

The eruption of the deciduous teeth, which are lost due to infectious processes or any other reason, may be delayed if the eruption of the permanent teeth occurs without the crown portion. The opposite also happens during the loss of deciduous teeth; the permanent tooth is in the root formation phase, accelerating the process of eruption. Many factors may be involved in early tooth eruption. Among them are warm climates, a middle and high socioeconomic level, hyperthyroidism, etc. Therefore, the expert must be aware of and consider all of this information in determining age, as isolated data can lead to gross errors.

For the expertise's area matter the pre-eruptive and pre-function, since the teeth are developing in these phases, where we can observe different degrees of mineralization of the crown and root using radiographs. After 7 years of age, this information will decrease and to 18 years the analysis is poorer, with only the third molars, which are not always present. Therefore, experts should always complement the exam with elements of clinical examination to obtain a more accurate conclusion about the age of the person. There are numerous

tables in the literature of eruption chronology, but these data should be used only if the examined person is in the same group of population studied in the table. Ideally, each region requires a study population that correlates with the chronology of the eruption to be reliable and successful.

Palate Rugoscopy

Technical support in the identification, palate rugoscopy is based on analysis of the wrinkles on the palate, where are seen the ridges, folds, wrinkles, among others. This study can be used when fingerprinting cannot be done, such as in cases of charring or amputation of the fingers. In the anterior part of hard palate there are numerous ridges in the mucosa with a variety of types; these may classified into 4 major types: curved, wavy, straight, and circular. It is proven that these wrinkles are unique, like fingerprints, unchanging, perennial, and subject to classification, which meets the technical and biological requirements for human identification.

Carrea considers four categories:

Type I-with wrinkles directed medially (toward the center of the sides) and slightly backwards (converging in the raphe palate).

Type II-with wrinkles directed perpendicular to the median raphe.

Type III-with wrinkles directed medially (toward the center of the sides) and slightly front-to-back (converging in the raphe palate).

Type IV-with wrinkles directed in different directions.

It is important to remember that you need the plaster models (dental records obtained from the dentist) as well as the molding of the victim or suspect, alive or dead, to the confrontation.

Anthropological Identification with Interest in Forensic Dentistry

Etymologically, anthropology means the science of man. It is the study of the evolution of man with regard to the physical and cultural aspects, origin, position in the zoological scale, and understanding of different ethnic groups and societies. Identity is the character set (anthropology), physical, functional or psychic, normal or pathological, that specifies a certain person (biotypology). The dentist who is engaged in forensic dentistry must complete a form with the anthropological data examined, noting the characters.

Somatoscopic data

Skin color should be considered as it appears where there is minimum exposure to sunlight, such as the skin under underwear. Also one should use a scale of Von Luschan [3]; in its absence, the expert must use common sense.

Skin color: Melanin is the most important factor to be studied, but beyond that, there are other factors to consider to establish the color of the skin, such as epidermis (thicker or thinner), circulating blood, and the influence of sunlight.

Hair: Determination keys to reach correct differentiation are based on macroscopic features, such as the shape, size, profile, and color of the hairs, as well as on microscopic characteristics of the cortical cuticular and medullary patterns [4]. The strand of hair has three layers: cuticle, cortex, and medulla. It also has an implanted part called the root, where we find the hair bulb.

For experts, the goal is to differentiate between human and animal hair. And the human hair has the following characteristics: it is cylindrical, flexible, and has a homogeneous color. Histologically, it has a thin cuticle and predominant cortex, and the medulla is not always visible. We can draw some conclusions about the individual's age from hair—as with gray hair or hair on newborns. Types of Hair: Straight, wavy, curly, kinky. Types of deployment can be seen in rows of circles, rectangles, and triangles. Colors include blonde (light, medium, and dark), brown (light, medium, and dark) and black. In addition, the albino has a total absence of melanin or red.

Eye color: Colors may be brown (light, medium, and dark), blue (light, medium, and dark) and green. Albino individuals have no pigment, and the pupil is red due to the reflection of the blood in the eyes.

Somatometric data

These are all of those elements that can be measured in humans, such as scale, height, size of a tooth, femur, etc.

Skull Elements

Sex estimation

After the hip bone, the skull is in second place with regard to diagnosis of sex (Table 3).

The elements that contribute to the distinction between the sexes are summarized in the table below

Boudoin index: This uses the dimensions of the occipital condyles. For the females it is short and wide whereas in males it is long and narrow, but this index provides a low percentage of accuracy, about 60%.

Boudoin Index=condyle width/condyle length x 100

Ethnic group estimates

With globalization, it has become more difficult to determine with certainty an individual's ethnicity.

	Female	Man
Mastoid and styloid process	Smaller	Bigger
Jaw	Less robust, muscular insertions not pronounced. Much flatter	More robust, with more pronounced muscle insertions. Very bulging.
Condyloid part of the occipital bone	Short and wide	Long and narrow
Weight	Skull lighter	Heavier skull
Mastoid Apophysis	Less developed, skull less stable when put on a flat surface	Prominent. Skull more stable when placed on a flat surface
Supraorbital ridge	Cutting edge	Rhomb
Articulation frontonasal	Curve	Angular
Glabella	Not salient	Salient
frontal	More vertical	More tilted back

Table 3: Distinction between the sexes.

Horizontal Index	Type of Skull	Ethnic group
<74.9	Dolichocephalic	Nordic Caucasoid (Scandinavian, English), African Black, Australoid
74.9-8.0	Mesocephalic	Mongoloid
>80.0	Brachycephalic	Caucasoid (central Europe)

Table 4: Horizontal cephalic index: in the horizontal plane is listed the maximum width to the length of the skull.

Vertical Index	Type of Skull	Ethnic group
>75.0	Hypsi skull	Mongoloid, African black
75.0-69.0	Meso skull	Caucasoid
<69.0	Plati skull	fossil skull

Table 5: Sagittal index: lists, in percentage, maximum height and maximum length in the sagittal plane.

Vertical Index	Type of Skull	Ethnic group
>98.0	Steno skull	Caucasoid (central Europe)
98.0-91.9	Metro skull	Mongoloid
<91.9	Tapino skull	Negroid, Caucasoid (south and north Europe)

Table 6: Cross Index: lists, in percentage, maximum height with a maximum length, in the frontal plane.

Facial Index	Type of face	Ethnic groups
>55.0	Dolichofacial	Nordic Caucasoid (Scandinavian, English), Polynesians, Arabs
55.0-49.9	Mesofacial	Black African
<49.9	Brachyfacial	Australoid, Mongoloid, Fossil skull

Table 7: Upper facial Index: lists, in percentage terms, the maximum height of the face with the maximum width in the frontal plane.

Nasal Index	Type of face	Ethnic group
<47.9	Leptorhino	Caucasoid
47.9-53.0	Mesorhino	Mongoloid
>53.0	Platyrrhini	Negroid, African, Australoid, fossil skull

Table 8: Nasal Index: Lists, in percentage terms, maximum nasal width to the height of the nose in the frontal plane.

Here are the following statistics for ethnic groups: (Table 4).

Horizontal cephalic index=width (eurio-eurio)/maximum length (glabella-metalambda) x 100

Sagittal index: Sagittal index: lists, in percentage, maximum height and maximum length in the sagittal plane (Table 5).

Sagittal index=maximum height (basion-bregma)/maximum length (glabella-metalambda) x 100

Cross index: Cross Index: lists, in percentage, maximum height with a maximum length, in the frontal plane (Table 6).

Cross Index=maximum height (basion-bregma)/maximum width (eurio-eurio) x 100

Facial index: Upper facial Index: lists, in percentage terms, the maximum height of the face with the maximum width in the frontal plane (Table 7).

Upper facial index=a maximum height of the face (nasal-próstio)/maximum width of the face (malar-malar) x 100

Nasal index: Nasal Index: Lists, in percentage terms, maximum nasal width to the height of the nose in the frontal plane (Table 8).

Age Estimative

For the cranial sutures: Over time, the cranial sutures suffer a slow process of ossification, with bone bridges in their interdigitations. The sagittal, coronal, and lambdoid sutures can be divided into three sectors with regard to timelines of ossification. Around 25 to 28 years is the end of the bone welding of epiphyses to diaphysis, and this is a sign of aging. This method must be viewed cautiously by the expert. He must take precautions and gather all available evidence to determine with more certainty the individual's age.

For the mandible angle, what matters in this analysis is the gonial angle, formed by the ascending branch and horizontal branch of the mandible. In newborns, it ranges from 160° to 170°. With advancing age, it declines and reaches adult values between 95° and 100°. Thus, it increases each year at a rate of 0.186° and reaches, in the elderly, between 130 and 140°.

Study of Bite Marks

Bite marks are defined as the impressions recorded by the teeth on one surface by one or both arches. Didactically, the wounds produced are classified in literature in two ways: as blunt [5] or blunt with contusion [6]. Recently, they have been accepted as evidence, and the methodology to obtain samples is still an object of study. Bite marks can be found in various scenarios such as in foods, objects, and human skin usually linked to homicides and sex crimes representing a powerful tool for research.

This study does not encompass all of the requirements of an ideal study, falling short with regard to practicality, as it requires the production of trays, models, and photographs; this complicates the process. In addition, the immutability can undergo changes over time, as for example with the use of braces and tooth extraction. The bite marks impressions are called support, which may be animate or inanimate. The first one can be human, if left in the victim's body, in life or post mortem; or animals, when in defense or fighting. They may be inanimate, which can be left in pencil, in soap, or in food, which may be fruit, candy, or other genres. A differential diagnosis should be made between humans and nonhumans marks. The humans are recognized by their shape and size, with characteristic elliptical or ovoid.

Human skin has different thicknesses depending on its location on the body. The bite of a flat surface is different from one in a curved surface (concave or convex). The concave surfaces are rarely subject to bite, the opposite happens with the convex surfaces such as those which are seen in the sinuses, nose, ears etc.

The protocol procedure in bite marks on suspects is suggested by the *American Board of Forensic Dentistry* - ABFO [7]:

- Registration of clinical dentistry and the time elapsed between the production and examination of the wound;

- Photographic record, including several extra and intraoral X-rays, observing the arches in occlusion and maximal mouth opening.

- Extra-oral clinical examination of tissues, bone structure, and muscles.

- Complete registration and clinical examination intraoral, which may include saliva, tongue, and the periodontal condition of the suspect;

- Impressions of the dental arches;

- Registration of the bite in plate of wax, observing the occlusal relations, to study the dinamic of wound;

- Obtaining plaster models from the impressions made.

On the victim, the expert should describe the wound found by identifying the color, shape, size, type of injury (bruise, injury, loss of substances etc.), abrasion, bleeding points, etc.

Afterward, he should collect the saliva on the surface of the wound [8]:

- First cotton swab should be moistened with distilled water and swept across the region, leaving it to air dry;

- Second swab passing it over the same area;

- Place both swabs, in dry paper envelopes and refers them to the laboratory;

- Send to a DNA laboratory a blood sample from the victim; it is important to establish the DNA profile of the victim, as blood cells or skin may contaminate the saliva swabs.

The photographs should be made using a scale of reference, which must be positioned on the same plane or adjacent to the brand. The use of the scale allows the lesion to be measured as close to true size. In addition, other photographic shots should be taken to reveal all aspects of the region, even without the use of a scale. For the molding of imprints left on the skin surface, we can dissect it in or make a withdrawal in block, followed by buffered formalin fixation. But before, it is done a hoop using wax or plastic to keep the tissues in place with 4-6 stitches in the skin. So this tax will be distributed within the molding material. There is no indication of which material should be used, but preferably it should be alginate or silicone. It is known that alginate has little stability over time, so silicone is the material that is more stable.

Forensic Dentistry in Forensic Genetics

Since 1953, when Watson and Crick [9] discovered the double helix structure of DNA, there has been a growing shift in many scientific areas. The first DNA tests for human individuality were developed by Sir Alec Jeffreys [10], who analyzed regions of major polymorphisms that allow identification of individuals. Thereafter, the findings of different methods for each type of material extracted have moved the field of forensic genetics.

Studies in forensic dentistry and forensic anthropology alone solve many cases of identification, without the need for an expensive technological apparatus, contrary to what one sees in a molecular biology laboratory. Historically, fingerprints have been used for identification, but in some situations, they may be missing or damaged, as in cases of amputations of fingers, fire, etc. As with fingerprints, the forensic dentistry analysis depends on dental records of the victim with which to compare them, but sometimes these may not exist. Therefore, DNA research has been widely used for identification; even with tiny amounts of material or with degradation, it is possible to attain positive results.

Furthermore, although various studies have been proposed to analyze the characteristics of the skull, face, and jaw, they do not cover the different types of population and thus to choose which of the studies is better to associated the measures that we did.

Several biological materials may be employed to isolate DNA and conduct laboratory tests for human identification, including bone tissue, hair bulb, biopsy samples, saliva, blood, and other body tissues. It is possible to obtain DNA from virtually all human body tissues, but there are variations in the quantity and quality of the DNA extracted from each tissue [11].

Tooth structures have been prioritized for DNA extraction, because the pulp cavity provides a stable environment for DNA, especially when the body was that of a victim of fire, explosion, or other adverse situation. In addition to the teeth, saliva may be a source of genetic material, because it can be collected in a simple, safe, nontraumatic way that is easy for children. It can be extracted from stains on clothing, bite marks on the skin, seals, etc. [12].

Mitochondrial DNA

The mtDNA is found in the cytoplasm of the cell, unlike the genomic DNA, which is the cell's nucleus. It provides information on the inheritance of our brothers and close relatives in the maternal lineage. Its importance lies in the fact that a single cell has more than 5,000 copies of mtDNA and is associated with resistance to enzymatic digestion. Therefore, the study of mtDNA is used in old tissues such as teeth, bones and hair. The methodology used is the amplification of mitochondrial DNA by PCR followed by sequencing [13].

In forensic samples, the study of DNA (genomic and mitochondrial) is usually performed by STR (short tandem repeats) analysis, which can be defined as hyper variable regions of DNA that present consecutive repetitions of fragments that have 2 to 7 base pairs (bp). The VNTR (variable number of tandem repeats) testing, which may present short repeated sequences of intermediate size (15 to 65 base pairs), is rarely used in forensic analyses due to the poor quality DNA provided with this method. The most valuable STRs for human identification are those that present greater polymorphism (greater number of alleles), smaller size (in base pairs), higher frequency of heterozygotes (higher than 90%) and low frequency of mutations [2].

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