DENTO-MAXILLO-FACIAL RADIOLOGY AS AN AID TO HUMAN IDENTIFICATION

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ABSTRACT

Analysis of some anatomical structures of the face using radiographs is fundamental for human identification. The position of the postmortem skull relative to the radiographic machine and the film, as well as the exposure time, are the greatest problems found by the forensic dentist. In view of this fact, some recognised radiographic techniques that are used *in vivo* must be adapted. This paper shows that simple devices can make the process easier and that variation of kVp or exposure time in different situations may increase the quality of the radiographs.

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Key words: human identification, radiology, radiographic techniques

INTRODUCTION

Identification by means of dental elements is a process known to have existed since 49 AD, when the first case was recorded. Agripina, Nero's mother, ordered her enemy Lollia Paulina to be sacrificed, demanded her head and was convinced only after Agripina had found traceable signs of her dentition. This identification process continued to be performed empirically for centuries, until Oscar Amoëdo published "L'Art Dentaire em Médicine Legale" in 1898, where he suggested that a uniform system should be used internationally to perform an odontogram, a procedure that eventually gave rise to Forensic Dentistry.[1]

In addition to a clinical examination and the annotations on a patient's clinical file, the forensic dentist can make use of dento-maxillo-facial radiography. When bodies are to be identified, radiographs are made of the deceased person and compared with any radiographs of the presumed individual when alive. The following anatomical details should be used as parameters: tooth and root shape, missing and existing teeth, residual roots, supernumerary teeth, attrition or abrasion, coronal fractures, degree of bone reabsorption due to periodontal disease, bone pathology, diastemas, shape of the cavity fillings and cavity liners, dental caries, endodontic treatment, intraradicular posts and intracoronary pins and dental prostheses.[2-6] Several papers also denote the importance of radiography for human identification by the comparative method using trabecular bone patterns,[2] frontal and maxillary sinuses,[3,7] cephalometric[8] and dental radiographs,[9] and growth of finger phalanges.[10]

In cases where there are no previous records to serve as a reference for comparison an alternative is to obtain the most amount of information from the deceased in order to build a profile to assist identification. Sassouni,[11] as well as several other authors,[12-17] reported the great diversity of methods to estimate age through: the chronology of third molar eruption,[12,13] formation of the dentition[14-17] and sutures. Estimating gender by dental anatomy[18,19] and by cephalometric radiography, as well as determining ethnic groups by dental anatomy, are also addressed by Sassouni.[11]

There are several possible radiographic techniques that may be used on corpses to aid human identification. However, if these are performed incorrectly, either antemortem or postmortem, the result may hinder effective identification. Many forensic odontologists have adapted techniques to address the problems of postmortem radiography. The methods presented here are a simple and cost-effective alternative. Radiographic factors that may influence accurate identification are also discussed.

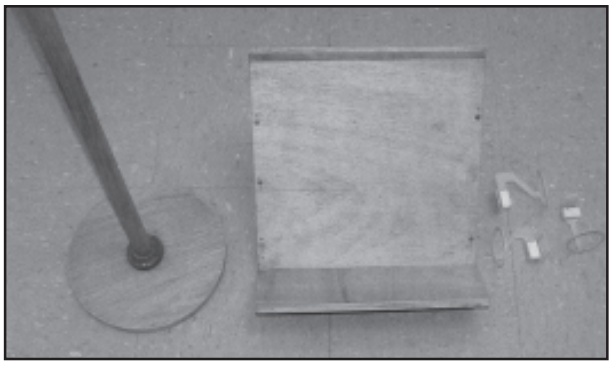

Fig.1: *Supports used for the skull: wooden pole, inclined plane and periapical film support*

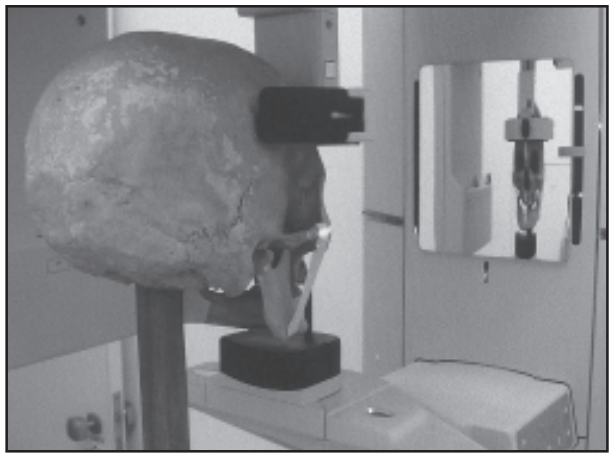

Fig.2: *Skull placed on a wooden pole and positioned in the panoramic x-ray machine*

MATERIAL AND METHODS

About 90% of the anthropological forensic cases that we examine are cleaned skulls, which had already been studied by other forensic professionals. The decomposed tissues are cleared away prior to examination using techniques by Snyder, Burdi and Gaul.[20] To simulate this, skulls retrieved from the archives of the Medical Legal Institute of São Paulo, Brazil have been used to demonstrate techniques that we have found useful in casework.

In general, radiographic film must be placed parallel to the area of interest and x-ray angled perpendicularly to the skull.[21] This presents problems in machines designed for living patients. Fixation supports must be used for the skull to be radiographed in such a way that correct positioning of the skull(s) may be achieved for each technique to be used.

We have used an intraoral unit (Siemens* 70 kVp; 7mA; 0,64s exposure), an extraoral x-ray machine (Instrumentarium-Orthopantomograph†; 81 kVp; 12mA; 0,4s of exposure and 15s for the panoramic technique) and also the following apparatus: a wooden pole with circular base, a wooden inclined plane and crepe paper (to articulate the mandible). The inclined plane is particularly important to individualise one region of interest in the mandible, preventing anatomical structures overlapping. It is fundamental that the positioners be made of wood, since the density of this material allows the x-rays to pass through without interfering with the final image (Fig. 1). Han Shin positioners§ are used for intraoral views.

Radiographic Techniques Adapted for Postmortem Skulls

1. **Postero-Anterior** (to assess maxillofacial and frontal sinuses)
   - •Skull: meatal-orbital line 90 degrees from the film
   - •X-ray beam: parallel to the meatal-orbital line
   - •Central point: midway between the occipital protuberance and the chin, level with the mandibular angle
   - •Support used: 1.5m wooden pole with a circular base 25cm in diameter cephalostat.

2. **Towne** (to assess the condyle)
   - •Skull: occipital part turned toward the film, meatal-orbital line 90 degrees from the film
   - •X-ray beam: 30 degrees from the meatal-orbital line
   - •Central point: 5cm above the nasion
   - •Support used: 1.5m wooden pole with a circular base 25cm in diameter/cephalostat.

3. **Lateral Technique** (to assess facial bones, sinuses and cranium)
   - •Skull: on the cephalostat to standardise the skull positioning, as used in orthodontic assessment
   - •X-ray beam: entering perpendicular to the film and parallel to the line formed by the infra-orbital foramina
   - •Support used: 1.5m wooden pole with a circular base 25cm in diameter/cephalostat.

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† Instrumentarium Imaging, Tuusala, Finland
§ Han Shin Technical Lab, Japan

4. **Panoramic Technique** (to assess adjacent structures related to all teeth)
   •Skull: positioned according to the cephalostat (Fig. 2)
   •Support used: 1.5m wooden pole with a circular base 25cm in diameter

5. **Lateral Oblique Projection** (to assess mandible body and retromolar region)
   •Skull: median sagittal plane parallel to the chassis and inclined 60 degrees in relation to the horizontal plane to assess mandible angle and mandible ramus (Figs. 3 and 4) or median sagittal plane turned in 30 degrees towards the chassis and inclined 60 degrees in relation to the horizontal plane to assess mandible body.
   •X-ray beam: rests on the mandibular angle
   •Support used: a wooden inclined plane measuring 22.5cm x 22.5cm x 32 cm, with the following angles: 45°, 45°, 90°, and a base to position the skull, measuring 35cm in length by 12cm in width, perpendicular to the inclined plane.

6. **Intraoral Techniques** (to assess teeth and adjacent bone structures)
   •X-ray beam: vertical angle is varied according to the antemortem radiograph, in order to obtain the most plausible and approximated comparative image.
   •Support used: Han Shin positioner to hold the film

DISCUSSION

Humans have 32 teeth that, in addition to having variable anatomical characteristics, may also be implanted in the bone in several ways, or may contain restorations of differing positions and materials or prosthetic reconstructions of different shapes. All this ensures the individuality of each dentition.[11,22] Teeth are relatively indestructible, and, as such, represent important evidence in the identification process.[23,24]

Both the teeth and the maxillary and mandibular bones may be visualised in intraoral or extraoral radiographs. Hence, the use of radiographs becomes fundamental in identifying humans. Since the great majority of the population today has already had some type of radiograph taken at the dentist's or the doctor's office, the records of these professionals provide a vast source of information that should be kept responsibly in an organised file.

These radiographs may be compared with that of the supposed deceased individual in order to aid identification. However, in so doing, the expert must observe some fundamental points such as the position and fixation of the skull relative to both the x-ray machine and the film position.

It is important that the expert be aware of some of the limitations he/she will come across when

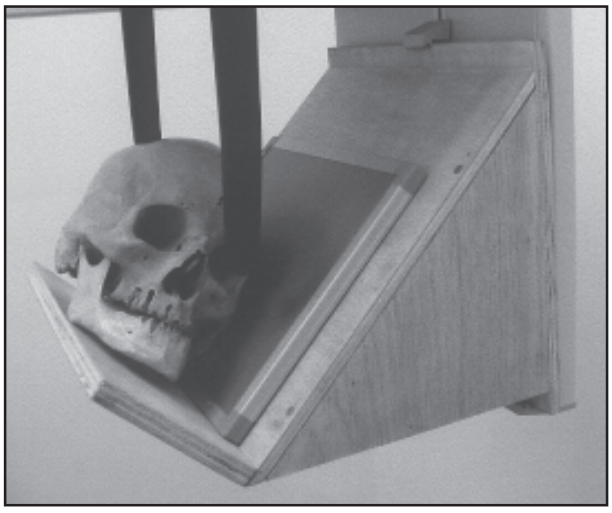

Fig.3*: Skull placed on the inclined wooden plane adapted to the chassis holder of the teleradiography x-ray machine to make lateral oblique radiographs of the mandible for angle and body*

Fig.4*: Lateral oblique radiograph of a mandible for angle and body obtained with the same positioning as the previous figure*

interpreting the images and comparing them with those of the supposed individual when alive. It is not always possible to reproduce the exact radiographic technique used before, especially if a radiograph was made by the bisecting plane technique of intraoral films. Obviously, the best results are obtained when the angle of the film is the same as that of the original film. Therefore, several attempts should be made by varying the angle, as described. Greater approximation will be possible if the size of the canal and the shapes of the restorations are used as parameters.[25]

The time interval between the antemortem and the postmortem radiographs may lead to a number of changes in both the teeth and the supporting bone.[3] Although the dental crown may be modified by surgical procedures, or by a pathological process such as dental caries or attrition, the pulpal outlines often remain intact.[26] Due to recent preventive techniques there has been a reduction in restored teeth in the population, leading to considerably fewer parameters for comparison.[27]

It is also important to note that the beam may travel through structures with different thickness when comparing the antemortem to the postmortem exposure, i.e. an inflammatory process or increased cheek thickness may cause a change in the density of the image obtained in the antemortem radiograph as compared with the post mortem radiograph. Teeth and bones that have been incinerated or immersed in water for a long period of time, or that have been subjected to other effects of nature, may show variation in structural density, or in the material used to restore the teeth.[25] Therefore, when the density of the radiographed structure is greater, the kVp to be used should also be greater, and vice-versa.[28] That way, the radiograph will qualitatively approximate the antemortem radiographic image.

A dry skull has a lower density than a live skull; therefore, the kVp to be used should be lower. Skulls with vestiges of soft tissue should be exposed with half to two-thirds of the normal exposure time.[21,29] Obviously, in machines having fixed kVp and milliamperage (mA), the only variable factor is the exposure time. If it is increased, the radiograph becomes denser.

Better film processing results are obtained when the visualisation technique[25] is used, since various time settings may be used according to different bone densities, unlike that afforded by the automatic process. It must further be stressed that old radiographs that are very dense (dark) may be "improved" using Farmer's manipulated solution[29] (distilled water-1 litre, potassium ironcyanide 30 gr, sodium hyposulphate), which lightens radiographs. This toxic solution should be handled carefully. The technique of washing, fixing, rewashing and drying helps decrease the incidence of radiographic discolouration.

Another resource available today is radiograph scanning and digitalisation techniques. Mathematical treatment of the image can alter the initial appearance of the radiograph, especially in terms of contrast, brightness and density. Other numerous software features as noise reduction filter, highlight, inversion or zoom can be used looking to improve the image. This treatment results in change to the original image and must be carefully documented in order to withstand legal scrutiny.[30] Several different measurements may also be made of both antemortem and postmortem radiographs, comparing them by way of the image subtraction technique.[31] New technologies may open new avenues for this type of identification. The Internet may be useful in international cooperation efforts to identify bodies by allowing the efficient transfer of images.

CONCLUSIONS

1. The teeth, their natural anatomical characteristics and those introduced by dental treatment, as well as the way they are implanted and the bone architecture, are fundamental to individualisation in human identification.

2. Intraoral and extraoral radiographs are an effective, cheap and safe method of human identification by comparison.

3. Radiographic comparisons may be carried out using several radiographic adapted techniques, aided by devices that make dry skull fixation easier, in order to obtain correct positioning.

4. In order for the comparative technique to be effective, multiple exposures should be made using several different angles, and using canal size and restoration shape as parameters of comparison for approximate identification.

5. kVp or exposure time may have to be changed depending on the density of the structure to be radiographed.

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