DENTOMAXILLOFACIAL RADIOLOGY IN FORENSICS: A REVIEW

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Abstract:
The present review article aims at discussing the various trends evolved in forensic dentistry, particularly referring with the usage of radiographs. Since the radiographs are the quick, easy, simple, economical and nondestructive method of obtaining information about age, sex, race of the victim, it is an indispensable aid in identification. With the advancement of newer technologies, more accurate information is obtained for identification as well as in the facial reconstruction of the unknown deceased person. This article gives an overview of different radiographic modalities for identification in oral and craniofacial region. To obtain the most reliable outcome in identification it is necessary that one applies most of these techniques repetitively with appropriate knowledge.

Keywords:
Introduction
Forensic is derived from a Latin word ‘forum’ where legal matters are discussed. Odontology refers to the study of teeth or dentistry. Federation dentaire Internationale [FDI] defined forensic dentistry as the branch of dentistry in the interest of justice deals with proper handling and examination of dental evidence with the proper evaluation and presentation of dental findings. Human dentition is one of the most reliable means of identification. Its uniqueness has been calculated mathematically and has been stated that about 1.8X1019 possible combinations of 32 teeth being intact, decayed, filled, missing may be present. The enamel is the hardest tissue in the body and the dentition is well insulated by the supporting alveolar bone and the oral musculature and thus likely to survive the outward damaging influences like fire, explosion, and putrefaction in water or soil. Additionally, teeth are also relatively less affected by internal disturbances like nutritional and endocrinal disorders. When visual identification becomes impossible in tragic incidents, dental evaluation sheds light on the age, sex, nationality of the deceased person.

Forensic Radiology
Forensic radiology is an integral branch of forensic medicine. It plays an important role in various criminal investigations which are helpful in determination of identity, evaluation of different injuries, various criminal and civil cases. The various modalities of radiology like X-rays, computed tomography (CT), magnetic resonance imaging and ultrasonography etc. can be used depending on various forms of cases and their requirements in routine investigations. The main advantage of using radiographs in forensic odontology is that it helps in overcoming various international scenarios in identification system that may overlap or give conflicting results and more importantly their acceptance in courts of law as legal evidence.

Historical Review:
The first recorded case of dental findings for identification was made of a rich roman women Lollia Paulina, between 49 and 66 AD who was identified after her death through her unique arrangement of her teeth.8 In India,1194 AD, King Jai Chandra of Canouj, was identified by his artificial teeth after his martyrdom in the battlefield.9 Saunders in 1837 was first to publish a pamphlet entitled, “Teeth a test of age”, regarding dental implications in age assessment. The first case where dental evidence was accepted in the court was of Dr George Parkman in 1849. The applications of radiology in forensic science was first introduced in 1896 by Prof. Arthur Schuster, just a year after the discovery of X rays, to demonstrate the presence of lead bullets inside the victim's head. Schullerin 1921 was the first to propose the comparative identification of the radiological images of the frontal sinuses with plates formerly taken. Culbert and Lawin 1927 were the first to describe the complete radiological identification of the skull by using pneumatic cells of the sinuses. Since then radiographs has been

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used widely for identification in mass disasters as well. In the year 2004, tsunami devastation in the Indian Ocean, about 54.16% of non-Thai victims were identified by dental status in Phuket/Thailand. Antemortem information, particularly radiography and treatment charts were collected from patient's native country. Postmortem dental investigations comprised of periapical radiographs, two bitewing radiographs and five digital photographs.12

Utilization of images in Forensic Dentistry:

In cases where the identification of a corpse is required, radiographic images of the deceased can be obtained and compared with any ante-mortem radiographic image of the presumed person. The following anatomical details can be adopted as parameters: shape of teeth and roots, missing and present teeth, residual roots, supranumerary teeth, attrition or abrasion, coronal fractures, sign of bone reabsorption resulting from periodontal disease, bone pathology, diastemas, cavities shapes and lines, dental cavities, endodontic treatment, intraradicular and intracoronar posts and dental prostheses.13-15 Many studies also highlight the relevance of radiography in human identification through comparative methods utilizing patterns of trabecular bone, frontal sinuses and maxillas, dental radiographic images and cephalometry and increased fingers length.16-18

Conventional Radiography:

The identification technique utilizing conventional radiography is based on the comparison between ante-mortem images recorded in dental offices and centers with post-mortem radiographic images. Much information can be obtained from these images. This method allows the observation of anatomical characteristics such as coronal shape and size, pulp anatomy, positioning and shape of the alveolar bone crest, besides unique and individual characteristics resulting from dental treatments.19

Digital Radiography:

Until recently, the greatest part of dental restoration materials was metal and therefore radiopaque. Peculiar characteristics of every restoration could be easily observed on conventional radiography. However, the process of identification based on conventional radiography became more difficult because of the dissemination of prophylactic dental treatments and the consequential, significant reduction in the incidence of cavities, particularly the same time, the microelectronics and the decrease in costs of computational equipment has allowed the development of more powerful and reliable techniques for comparison of radiological images with application in forensic dentistry.19 Innumerable variations of digital radiology techniques can be found in the literature, but, essentially, the method comprises the following steps: 1) radiographic images digitization with the aid of a scanner, video camera or, yet with images acquisition directly from a x-ray system coupled with a computer with monitor, printer and CD-ROM recorder; 2) images processing through an appropriate software, allowing comparisons based either on images superimposition, interposition or subtraction.20 These modern techniques allow an accurate analysis of the spatial relations of teeth roots and supporting structures on ante- and post-mortem images. There are softwares with resources for images rotation, translation and scaling, facilitating the correct alignment between ante- and postmortem radiographs without the necessity of new exposures.22 It is important to observe that differences in the geometry between radiographs represent the main factor of error in this type of technique, and the above mentioned correction is essential to reduce the noise resulting from the process of image subtraction.21

Computed Tomography:

Conventional, two-dimensional or three-dimensional computed tomography (CT) is a useful imaging method in the process of human identification, and presents innumerable advantages in this field as compared with the traditional radiographic projection. Firstly, because this method is free from the problem of structures superimposition beyond the plane of interest, and also for allowing the visualization of small differences of density.24 Additionally, CT presents other advantages, such as image segmentation – an important resource in cases where internal points must be evaluated -, easy image manipulation, imaging quality with excellent color scale and transparency, volume, area and both angular and linear measurements can be obtained. An ante-mortem CT image provides information which can be utilized in the construction of a post-mortem facsimile image, considering that craniometric points can be precisely located and measurements can be accurately performed.25 Besides, the film includes a complete description of the radiological protocol, with the positioning of the patient, angulation, slice thickness, kV, exposure time, size of the visual field, etc. Name, age and sex of the patient, as well as name of the assisting physician, name of the hospital, type of scanner utilized and other relevant information are also included. Individually, the films indicate the imaging plane and slice thickness. Currently, slice thicknesses as low as 1.0 mm can be obtained.26 Anthropologically, CT has been utilized in the study of skulls and also, in the forensic context, as an additional resource in processes of identification. Additionally, studies have demonstrated the applicability of facial reconstruction by means of 3D CT for the purposes of individual identification.24

General Identification through Radiology:
In cases where previous records are not available for comparison, an alternative strategy is the obtention of the largest amount of information about the deceased in order to construct a profile as an aid to personal identification. Although radiology plays an invaluable role in the differentiation between human and animal bones through the analysis of the bone tissue density, its contribution to the determination of age can be much more significant. During life, the bone tissue develops from ossification centers and mature to a complete development. This process is continuous and is completely finished with the epiphyseal fusion. This development is followed-up and studied by radiological methods in order to establish a chronology, allowing the age estimation. The relationship between bone and chronological ages depends on variables related with the individual organism and with the environment; this explains the higher or lower error rate, depending on the method utilized. Other parameters which contribute to the age estimation through the teeth evaluation can be mentioned, as follows: deciduous eruption, crown and root mineralization, tooth area/pulp chamber area ratio, dental erosion. These measurements of changes related to the age of dental tissues present very good results in general identification, considering that teeth are less susceptible to nutritional, hormonal and pathological changes, particularly in children. So, age estimation in children can be based on the analysis of the developmental stages of the dental elements in the permanent dentition observed on panoramic radiographic images and classified according to the table of dental mineralization chronology. On the other hand, age estimation in adult individuals can be achieved by radiological determination of the reduction in size of the pulp cavity resulting from a secondary dentin deposition, which is proportional to the age of the individual. The physico-chemical analysis of the bone demonstrates an increased carbonate deposition with aging. Also, an increased decalcification is observed with the consequential decrease in bone density. There are morphological characters on some bones that should be analyzed separately. So, an atrophic mandible related to dental loss corresponds to a characteristic suggestive of an aged individual. With aging, cranial sutures ossify (synostosis) and disappear, therefore this is a parameter to be taken into consideration in age estimations. So, radiology plays an extremely significant role in age estimations focusing on epiphyseal ossification centers whose investigation results in higher reliability.

Radiography in Forensic Odontology: Future prospects

Modalities such as transportable multislice CT perform postmortem dental scans in a short time. An added advantage is that the processing software allows comparison of every possible ante-mortem dental radiograph for the purpose of identification. In one report dental processing software for computed tomography (Dentascan) has been used for scanning three corpses. In all three cases panoramic reconstruction of the image could be obtained which could be compared to ante-mortem records. The images were clear enough to differentiate structures like enamel, dentin, pulp, alveolar bone and restorations. Conventional radiography was only required in cases where streaking artifacts were produced with CT images. However a group of researchers have suggested the use of high resolution eLU-CT (eXplore Locus Ultra flat panel CT) to reduce problems like streak artifacts caused by metallic dental fillings. “Radiograph-like images” reconstructed using CT in postmortem cases have been used wherein conventional radiograph like images can be simulated to compare with ante-mortem records. A semi-automated image analysis software has also been devised to perform this comparison. In contrast in conventional approach, one recent research paper highlighted a new digital technique, wherein comparison tooth root morphology and spatial orientation of the roots between ante-mortem and postmortem radiographs has been used for identification. Dental biometrics is a new innovation utilizing dental radiographs for human identification. This system matches dental radiographs in two stages. The first stage is called extraction, which uses anisotropic diffusion to improve the images and a mixture of gaussians model to segment the dental work. The second stage termed as matching involves tooth-level matching, computation of image distances and subject identification. Making use of these steps a comparison of the ante-mortem and post mortem radiographs is carried out.

Conclusion

Radiographs are one of the excellent tools in the field of forensic dentistry. Forensic odontologist can rely on radiographs for age estimation with the various time tested methods, though multiple methodologies should be applied before arriving at a conclusive identification such as probable identification, possible identification, insufficient information or exclusion. Though dental and craniofacial radiographs are important assessment tools in race, gender and stature estimation, due to diversity in human physical constitutional make up, should also be supported by other forensic methodology and radiographs of other parts of the body. Recognizing its importance, the radiographic storing and record keeping should be upheld in all the dental clinics and institutions as per the rules of the land. Further the forensic team should always be well acknowledged with the dental and craniofacial radiography and its forensic significance and thus include it in its normal protocol.

Reference


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