Xournals

Academic Journal of Anthropological Studies

ISSN: 2581-4966 | Volume 05 | Issue 01 | April-2022

Alveolar Bone - As a Valuable Evidence in Forensic Investigations - A Review

Amisha Nayak[1], Dr Sandhya Tamgadge[2]

Available online at: www.xournals.com

Received 26th August 2021 | Revised 19th October 2021 | Accepted 12th March 2022

Abstract:

Tooth is a prime hard tissue remain for forensic identification. Often in the absence of teeth for forensic investigations, Bones can provide enough information to recognize the deceased and bring about justice for the victim and convict the culprit. Estimation of Age, Sex, Stature and Race in a forensic sample is difficult due to its varied response towards extrinsic and intrinsic factors over the individual's lifetime. Numerous studies on tooth structure are performed and collated using these parameters. However, studies conducted with Alveolar Bone as a forensic sample are limited with no collation. Alveolar bone plays a vital role in identifying the deceased due to its long vitality even after the decomposition of the soft tissues of the unknown deceased. Numerous method for person identification, such as Morphological methods, Radiographic methods, Histological methods, Digital methods and Molecular methods applied in various studies of forensic investigations are compiled in this review. Alveolar bone as a diagnostic tool could be contemplated as the methods in forensic investigations owing to an array of methods used for identification especially in edentulous individuals. This review describes Alveolar Bone as a vital tool in forensic diagnosis using various diagnostic methods of forensic personal identification.

Keywords: *Alveolar Bone, Forensic Odontology, Diagnostic Tool, Dentistry.*

Authors:

1. *Undergraduate student, D Y Patil University, School of Dentistry, Navi Mumbai, Maharashtra, INDIA*
2. *Professor, Dept. of Oral & Maxillofacial Pathology and Microbiology, D Y Patil University, School of Dentistry, Navi Mumbai, Maharashtra, INDIA*

Introduction

Forensic odontology is defined as the proper handling, examination of dental evidence, evaluation of dental evidence, presented in the interest of justice. The word forensic is derived from the Latin "forensic" which means "before the forum" from ancient Rome, while "odontology" is the study of the tooth and other orofacial structures **(Cordner and Tidball-Binz, 2017).**

There are various methods of personal identification in forensic odontology. Teeth are commonly found hard tissue used for evaluation. In absence of teeth, the alveolar bone could be considered as a second option**.**

Alveolar bone is a peculiar part of both upper and lower jaw bone i.e., maxillary and mandibular bone that supports the teeth. It forms as the teeth erupt and after the tooth is lost. The Alveolar Bone comprises an of-outer cortical plate and cancellous bone ***(*Suchetha *et al.*, 2017).**

History

As described by **Chidambaram Ramasamy (2014)**, the list of famous forensic cases worldwide (49 – 2013 AD) in which alveolar bone had been applied as a diagnostic tool. In the year 1820, the first case of a dentist as a professional witness was observed in Glasgow, Scotland. Rd. Pattison and two Glasgow medical students were held accountable for the desecration of the already buried grave of Mrs. McAlister. They were inculpated for disinterring the corpse and carried it to College Street Medical School to dissect for teaching. For identification, Mrs McAlister's husband presented the artificial teeth worn by his late wife, which were later fitted into the denture by Dr. James Alexander and was considered an important authentication in the court **(Pattison, 1910).**

The Parkman – Webster case was the first case solved by forensic odontology accepted by the United States court in the year 1849, where Dr Parkman, a professor at Harvard University, was murdered in 1849. John White Webster, who was a chemistry professor, and his colleague, was then speculated. On investigation, remains of the mandibular bone and artificial teeth were found, following which, the dentures were recognized by the dentist who had prepared the dentures three years prior to the death of Dr. Parkman. Further, Abraham Lincoln's assassin was identified using alveolar bone. On 1865, April 14, John Wilkes Booth absconded following President Lincoln's assassination. After 12 days, he was killed by Union soldier; even after that, the rumours of his escape persisted. To prove his death, the abnormal jaw and gold restorations were obtained after disinterring Wilke's body, and the parts were subsequently identified by the dentist who had constructed the restorations prior to his extermination **(Senn *et al.*, 2013)**.

The forensic recognition of Adolf Hitler was evaluated in 1945 after his suicide along with his wife on April 30, 1945, in Berlin. Hitler's skull fragments, pieces of the maxilla and mandible, along with a nine-unit's bridge were reclaimed from the Kremlin archives and were compared with those submitted by Hitler's dentist Hugo Blaschke. On Nov 10th 1944, Hitler was treated for a maxillary molar tooth infection. On obtaining Hitler's dental records, the construction of anterior bridges and the presence of periodontal problems settled his identity. The Queen Hatshepsut Mummy Mystery of 1458 BC was also noted and evaluated by DNA analysis of alveolar bone. The mummy was identified in the year 2007. Hatshepsut was the 5th pharaoh of the 18th dynasty of Ancient Egypt. Following her death in 1458 BC, Tomosis III destroyed all the monuments, defaced tombs and removed her references. During excavation, Howard Carter, who was a British archaeologist, found the tomb but her mummy could not be tracked. In 1903, after an investigation, two mummies were discovered, one of which belonged to Hatshepsut's nurse, Sitre. The unnamed, damaged, mysterious mummy was identified using a molar tooth, and DNA analysis, to be Queen Hatshepsut.

The Carla Terry Murder case was solved by 'Lucis'- an image processing software using alveolar bone. On January 28th 1991, Carla Terry's body was wrapped partially in a garbage bag and was abandoned in Hartford Connecticut. Two prominent thumb marks on the victim's neck were found, on which, the investigators concluded that her carotid artery was pressed and her breast was bit until she lost consciousness. A card retrieved by the police from Terry's pocket became a suspect, but the medical examiner could not compare the bite marks with Swinton's. In 1998, the cold case was proposed to Dr Gus Karazulas, Chief Forensic Odontologist, Connecticut State Police Forensic Science Lab who devoted years to link the suspect's bite marks with the victims using a new patented image processing software called 'Lucis', which amplified the bite mark which ultimately could find out fifteen points matched with Swinton's teeth and so, in March 2001, the suspect was declared guilty **(Ramasamy, 2014).**

Various biological structures in the human body are manoeuvred for the identification of the deceased, to

evaluate 'the big fours of person identification' namely Age, Sex, Stature, and Race. Alveolar bone is also a vital structure of the body to identify the deceased human by assessment of the structures employing the framework viz. by Morphological means, radiological means, histological means, molecular means and digital means.

Different Methods of Forensic Person Identification using Alveolar Bone

1. Morphological Methods of Forensic Identification using Alveolar Bone

All the biological structures in the Human Body are evaluated morphologically to determine the Age, Sex, Stature and Race of the individual.

Age Estimation - Number of whole and fragments of osteons, skeletal degeneration; Eruption and sequence and Appearance and fusion of centers of ossification are taken into consideration.

Sex Identification - Characteristic parameters found in male and female skulls are applied for analysis. A female skull is small, light with Rounded frontal bone(forehead); Pointed chin; Sloping or obtuse jaw angle whereas a male skull is Large, heavy with Sloping; less rounded frontal bone (forehead); Square chin and Vertical or acute jaw angle **(Latham and Miller, 2019).**

Stature Identification - Techniques such as measuring Glabella - inion length, Maximum Bi-parietal diameter and Auricular head height is calculated **(Ilayperuma, 2010).**

Race Identification - By observing the nasal opening, zygomatic bones, maxillary bones and teeth, the race of the individual can be identified **(Kanchan and Krishan, 2013).**

2. Radiographic methods of Forensic Identification using Alveolar Bone

Radiographic dental identification is of two types, namely comparative type and reconstructive type. The comparative type includes a comparison of antemortem radiographs and post-mortem radiographs. The reconstructive type includes biological profile fabrication using radiographs **(Vyas, 2019).**

Age Estimation - For age estimation, angulation of the cementum of the tooth can be used. According to the phases of Human Development, radiographic features are grouped under Prenatal; neonatal, and postnatal; Children and adolescents, and adult phases. For this, two methods commonly practiced include the 'atlas' and the 'scoring' method. In the "atlas method", mineralization (dental development) is compared with accepted standards, and in the "scoring method", dental development divided into various stages are assigned scores followed by statistical evaluation **(Acharya, 2011).**

Sex Identification - Novel approaches such as examining the morphology including symmetry, outline, septa and cells of the frontal sinus are considered of prime importance. The frontal sinus lies in the posterior part of the superciliary arch and between the external and internal faces of the frontal bone. Frontal sinus radiographs are used extensively as it is commonly exposed in sinus series investigations. Also, the frontal sinuses are larger in males than in females, with deeper upper borders of the frontal sinuses in the latter. According to a study by Camargo et al, radiographs of the frontal sinus for the examination have an accuracy rate of. 79.7% in sex determination **(Kumar *et al.*, 2015).**

3. Histological methods of Forensic Identification using Alveolar Bone

The normal bone structure incorporates a three-layered tissue with an outer circumferential lamellae, the middle layer of Haversian systems and circumferential lamellae in the innermost area. As a component of an osteon, the Haversian system, collagen fibres and concentric lamellae are also included. The scientific literature postulates that the difference in the histology of bone can be differentiated as contrasting bones of the corresponding skeleton, contrasting regions of the same bone, contrasting areas of the same section with different species and at different ages. The function includes elucidation of the developmental basis for the differences in tectonic patterns in random sections of Alveolar Bone tissue. The evolutionary history of each bone can be constructed, as former growth stages are recorded in the solid matrix of the bone **(Enlow, 1966).**

Age can be estimated by histological studies with clinical and anthropological research by Kerley, 1965; Wu et al., 1967, 1970; Stout and Teitelbaum, 1976; it is said that cortical bone turnover occurs at a predictable rate over individual's lifetimes. The length of time during which remodeling occurs would be the primary influence on how many secondary osteon creations (intact and fragmentary osteons) accumulate per unit of area **(Fernandes, 2011).**

4. Molecular Methods of Forensic Identification using Alveolar Bone

DNA persists in hard tissues extensively than in soft tissues due to the rigid structure and protection from DNA degradation.

The bond between DNA and the hydroxyapatite of hard tissues stabilizes it, preventing degradation and thereby also preventing gross bone and tooth reduction. Due to accelerating or decelerating factors affecting the biological degradation process, molecular taphonomy can be considered for analysis. Various environmental elements can be preserved in different bones of the same and different skeletons with variations in the attributes of DNA; and its yield across the bone. As a result, a depositional environment contributes to the degradation of molecules at rates contrasting the absolute age of the DNA sample. Also, the type and density of the bone favour DNA preservation. Steps for identification include decontamination of DNA; pulverization and subsequent incubation, grinding of sample in bone powder and DNA purification. Skeletal DNA retrieval includes maximizing DNA yield, minimizing DNA destruction, and removing constraints that may potentially interfere with the results. Different types include Nuclear and Mitochondrial DNA. This can be applied in cases of mass disasters and unidentified remains cases. Considering the future scope of forensic analysis, molecular methods are comprehensive. It optimizes Polymerise Chain Reaction (PCR) intensification of minuscule polymorphic loci and thereby generates DNA profiles from samples that were unsuccessful previously. Besides, adopting massively parallel sequencing are also helpful. Also, automated instrumentation will reduce the time taken for DNA profiling **(Latham and Miller, 2019).**

5. Digital methods of Forensic Identification using Alveolar Bone

Digital radiography is a potential remedy for extensive fatalities outnumbering the time for the identification of victims' descendants. Computer-based software's reduce the span of radiographic investigations with increased accuracy. Identification by conventional radiography has become arduous due to the presence of widespread prophylactic dental treatments and reduced cavities, predominantly in developed countries.

Despite the presence of countless variations, it consists of:

(1) Digitalisation of radiographic illustration by video camera, scanner, acquisition of image from X-ray system with a computer.
(2) Processing of images through software that allows comparisons based on superimposition, interposition or, subtraction of images.

By using this technique, accurate analysis of spatial relations of the roots, tooth-supporting structures, image rotation, translation and correct alignment on both ante-mortem and post-mortem images can be evaluated.

Forensic odontology plays a major role in the identification of individuals who cannot be identified visually or by other means. With the evolution of the technique, Computed Tomography (CT); micro-CT; Magnetic Resource Imaging (MRI); and Orthopantomogram (OPG); Cone-beam computed tomography (CBT), autopsy too, potentially aids in identification **(Vyas, 2019).**

Forensic Estimation of Time of Death using Alveolar Bone

The death time continues to be the major question during a death investigation Hence, the chronological date of events is beneficial in forensic investigations (as with ancillary scientific studies such as geology and archaeology), that is, the ability to create a theoretical timeline upon which the social interactions and events of the individual's last days assisting in either eliminating or incriminating others from an inquiry. The duration between the time of death and the estimation of the forensic specimen is essential besides routine parameters **(Swift, 2016).**

Knight and Lauder in the year 1967, conducted a study with 68 dated samples to produce a time-friendly method with accuracy. By using several predominantly physicochemical methods to test bones for known Post-Mortem Interval (PMI), the research was aimed at identifying which tests would provide the most information regarding the time passed since death. D Nile blue and dichloroindophenol staining, D Reaction with a mineral acid, D Nitrogen content, D Amino acid content, including "free" amino acids, D Benzidine reaction, D Ultraviolet (UV)-induced fluorescence, D Antihuman sera immunologic reaction and D Fat estimation was considered. It was culminated that sometimes, these methods failed to discriminate accurately between bones of antiquity and bones of forensic interest. Of the tests described, only four displayed correlation with the PMI **(Bernard and Lauder, 2015)**.

1. A specimen is said to be 30 months; tunnelling-within both the internal and external circumferential lamellae, recognizable histologically when fungi or bacteria infiltrate the mid-zone of the substantia compacta.

2. A specimen is said to be 5 years old when loss of immunologic activity is observed.

3. A specimen is said to be of 10 years when there is the presence of histologic changes which seem as erosive changes identifiable initially within the Haversian canals and the interstitial lamellae.

4. A specimen is said to be of 15 years when there is the presence of erosive, fungal and bacterial tunnels forming characteristic labyrinthine spaces.

5. A specimen is said to be of 50 years when loss of nitrogen is greater than 3.5% by weight is observed.

6. A specimen is said to be centenarian when there are less than 7 amino acids from the organic phase of bone with squandering of the inherent fluorescence pattern of the cut bone.

7. A specimen is said to be of 350 years when there is a loss of nitrogen greater than 2.5% by weight.

8. A specimen is said to be of 800 years when there is the progression of loss of inherent fluorescence pattern of cut bone.

9. A specimen is said to be an ancient bone when there is a specific loss of proline, / hydroxyproline observed in the specimen **(Bernard and Lauder, 2015).**

Craniofacial Superimposition Technique

Craniofacial Superimposition Technique involves the superimposition of an illustration from a retrieved cranium onto a premortem illustration of a suspected individual. It is widely applied to analyze the mysterious skull.

There are three types namely, the Photographic craniofacial superimposition technique, Video craniofacial superimposition technique and the Computer-aided craniofacial superimposition technique. **Damas *et al.* (2011)** considered existing methods whilst taking computer-based classification criteria to use in different processing stages.

The stages employed for the craniofacial superimposition system are -

(a) Face amplification and cranial modelling- This includes creating a digital skull model with the enhancement of facial images. This can be executed using a 2-dimensional image. Also, image processing techniques are applied to enhance the facial image adroitly.

(b) Skull face overlay- This stage consists of overlaying 2-dimensional or 3-dimensional cranial and facial pictures or overlaying a 3-dimensional model of the skull with a 2-dimensional image which was obtained in the previous stage.

(c) Decision-making- Investigation of the form and extent of soft tissue at various anatomical landmarks corresponds to this stage **(Damas *et al.*, 2020).**

Conclusion

Alveolar bone is of paramount importance in various spectrums of forensic identification such as radiology, histology, molecular biology, and digital identification technique. By studying these aspects one can find out the possible diseases incurred by the dead individual and also the root of fatality leading to the foundation of strong authentication in trials and also on humanitarian grounds.

References:

Acharya, Ashith B. "Accuracy of Predicting 18 Years of Age from Mandibular Third Molar Development in an Indian Sample Using Demirjian's Ten-Stage Criteria." *International Journal of Legal Medicine*, vol. 125, no. 2, Mar. 2011, pp. 227–33, doi:10.1007/s00414-010-0522-9.

Chidambaram, Ramasamy. "*A Select List of International Cases Involving Forensic Odontology (49–2013 AD).*" Research Gate, 1 Oct. 2014. www.researchgate.net/publication/313861401_A_Select_List_of_International_Cases_Involving_Forensic_Odontology_49-2013_AD.

Cordner, Stephen, and Morris Tidball-Binz. "Humanitarian Forensic Action - Its Origins and Future." *Forensic Science International*, vol. 279, Oct. 2017, pp. 65–71, doi:10.1016/j.forsciint.2017.08.011.

References:

Crawford, Bob. "Granville Sharp Pattison." *The Friends of Glasgow Necropolis*, www.glasgownecropolis.org/profiles/granville-sharp-pattison/#. Accessed 11 Aug. 2021.

Damas, Sergio, et al. "Craniofacial Superimposition Techniques." *Handbook on Craniofacial Superimposition*, 2020, doi:10.1007/978-3-319-11137-7_4.

Enlow, D. H. "An Evaluation of the Use of Bone Histology in Forensic Medicine and Anthropology." *Studies on the Anatomy and Function of Bone and Joints*, 1966, pp. 93–112, doi:10.1007/978-3-642-99909-3_7.

Fernandes, Paulo. "Bone Tissue Mechanics." *University of Lisbon*, Https://Tecnico.ulisboa.pt/Pt/, http://www2.dem.ist.utl.pt/~prfernan/.

Ilayperuma, Isurani. "On the Prediction of Personal Stature from Cranial Dimensions." *International Journal of Morphology*, vol. 28, no. 4, 2010, pp. 1135–40, doi:10.4067/s0717-95022010000400024.

Kanchan, Tanuj and Kewal Krishan. "Personal Identification in Forensic Examinations." *Anthropology*, vol. 02, no. 01, 2013, pp. 2–3, doi:10.4172/2332-0915.1000114.

Knight, Bernard, and Ian Lauder. "Methods of Dating Skeletal Remains." Human Biology, vol. 41, no. 3, Wayne State University Press, 1969, pp. 322–41, http://www.jstor.org/stable/41435775.
Kumar, Raghav, et al. "Forensic Radiology: An Emerging Tool in Identification." Journal of Indian Academy of Oral Medicine and Radiology, vol. 27, no. 3, 2015, p. 416, doi:10.4103/0972-1363.170478.

Latham, Krista E., and Jessica J. Miller. "DNA Recovery and Analysis from Skeletal Material in Modern Forensic Contexts." Forensic Sciences Research, vol. 4, no. 1, 2019, pp. 51–59, doi:10.1080/20961790.2018.1515594.

Senn, David, et al. "Dental Age Estimation." Manual of Forensic Odontology, Fifth Edition, 2013, doi:10.1201/b13744-9.

Stavrianos, Christos, et al. "Dental Age Estimation of Adults: A Review of Methods and Principals." *Research Journal of Medical Sciences*, vol. 2, no. 5, 2008, pp. 258–68.

Suchetha, A., et al. "Alveolar Bone in Health." IP International Journal of Periodontology and Implantology, vol. 2, no. 4, 2017, pp. 112–16, doi:10.18231/2457-0087.2017.0002.

Swift, Benjamin. "The Timing of Death." Essentials of Autopsy Practice, Springer, 2016, pp. 189–214, eknygos.lsmuni.lt/springer/143/189-214.pdf.

Vyas, Tarun. "Radiographic Determination: An Upcoming Aid in Forensic Radiology." Journal of the International Clinical Dental Research Organization, vol. 11, no. 2, 2019, p. 71, doi:10.4103/jicdro.jicdro_24_19.