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EFFECT OF GEOGRAPHIC VARIATION IN BIOARCHAEOLOGY: A FORENSIC ODONTOLOGICAL PERSPECTIVE

Dr. Vidya M Annegowda*	MDS Oral Pathology, Fellowship in Forensic Odontology Reader, Department of Oral Pathology, Dayananda Sagar College of Dental Sciences. *Corresponding Author
Dr. Krishnanand P Satelur	MDS Oral Pathology, Fellowship in Forensic Odontology Professor and Head, Department of Oral Pathology, Dayananda Sagar College of Dental Sciences.
Dr. Jeff Patrick	Intern, Department of Oral Pathology, Dayananda Sagar College of Dental Sciences.
Dr. Roseline Dsouza	Intern Department of Oral Pathology, Dayananda Sagar College of Dental Sciences.
Dr. Priyanka Kolakar	Intern, Department of Oral Pathology, Dayananda Sagar College of Dental Sciences.

ABSTRACT The combination of bioarchaeology and forensic odontology enhances our understanding of past populations, providing valuable data for reconstructing human history and cultural interactions. It helps bridge the gap between the ancient and modern world, offering insights into how human societies have evolved and diversified over time in different geographical contexts. Overall geographic variations in bioarchaeology and forensic odontology are crucial aspects of research and practice in these fields. They provide valuable information about the life experiences and origins of individuals from different regions, aiding in the understanding of past populations and assisting in forensic identification and criminal investigations. As research in these areas' advance, our knowledge of the effects of geographic variations is likely to become even more refined and comprehensive.

KEYWORDS : Forensic Odontology, Taphonomy, Geographic variations

INTRODUCTION

"Forensic odontology is a branch of dentistry which deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings in the interest of justice." [1]

Forensic odontology plays a crucial role in identifying human remains, especially in challenging situations like mutilation, burning, decomposition, and mass disasters. During catastrophic events such as industrial accidents, airline crashes, and natural calamities, forensic odontologists are essential. They provide expertise when traditional methods like fingerprinting or visual recognition are impractical due to decomposed, charred, or skeletonized remains. Their tasks include diagnosis, monitoring, referral, decontamination, infection control, surveillance, immunizations, medication administration, triage, and medical support. [2]

Bioarchaeology, also known as osteoarchaeology, studies human remains within archaeological contexts. It can extend to the examination of biological remains like fauna and flora found at archaeological sites. The primary goal is to enhance archaeological interpretations and gain insights into past cultural practices and patterns. Skeletal biology, a cornerstone discipline in physical anthropology, provides the groundwork for studying recovered human remains.[3]

In the United States, it exclusively pertains to human remains, while in England and other European countries, it encompasses the analysis of any biological remains discovered at archaeological sites. Bioarchaeology helps bridge the gap between ancient and modern worlds, providing insights into human evolution, diversification, and cultural interactions across different regions.

Implications Of Geographic Diversity In Dental Anthropology

The principal effects of geographic diversity in bioarchaeology encompass as follows
Migration and mobility
Temporal changes
Taphonomic factors
Climate and environment
Disease pattern
Dental trait and ancestors
Dental pathology and geography indicators
Bite mark and geographic source
Age and dental development [4]

1. Migration And Mobility

Understanding migration and mobility in bioarchaeology with a forensic perspective can provide valuable insights into the movement of ancient peoples, the connections between different populations, and the factors that influenced human mobility in the past.

This multidisciplinary approach combines elements of bioarchaeology, anthropology, genetics, and forensics to shed light on the movement of ancient populations and individuals. Here are some key aspects of this field:

a. Stable Isotope Analysis: This method reveals an individual's diet, geographic origin, and potential migration by analyzing isotopic composition in bones and teeth.
b. Skeletal Analysis: Clues from physical characteristics help determine if individuals were native to a region or migrated later in life.
c. Ancient DNA Analysis: Genetic information tracks movement of specific lineages and confirms relationships among buried individuals.
d. Archaeological Context: Foreign artifacts or burial practices indicate migration or contact with other groups.
e. Forensic Techniques: Facial reconstruction and trauma analysis provide insights into an individual's life and risks faced during migration.
f. Historical Data: Combining bioarchaeology with written records and oral histories enriches our understanding of migration.
g. Health Impact: Studying migration sheds light on diet, disease transmission, and overall health in ancient populations.
h. Case Studies: Researchers explore specific migration events, such as during historical collapses or colonization.
i. Ethical Considerations: Respectful treatment of human remains and collaboration with descendant communities are essential.[5]

2. Temporal Changes

Temporal changes in geographic variation in bioarchaeology, particularly from a forensic odontological perspective, refer to how factors affecting the preservation and analysis of skeletal remains have evolved over time. Understanding these changes is essential for interpreting historical or archaeological remains accurately. Here are some key aspects to consider.

a) Taphonomic Changes Over Time:
Climatic Changes: Climate shifts over centuries or millennia can influence the preservation of skeletal remains. For instance, if an area that was once temperate becomes arid due to climate change, the

taphonomic processes may change accordingly, affecting bone preservation.[6]

b) Cultural Practices:

Funerary Customs: Changes in burial practices and rituals over time can impact how skeletal remains are preserved. For example, shifts from burial to cremation or changes in burial depth and orientation can affect the likelihood of skeletal remains being recovered and their condition.[7]

c) Technological Advancements:

Forensic Methods: Advances in forensic odontology techniques and technologies have allowed for more accurate analysis of dental remains over time. For example, the use of digital radiography and 3D scanning has improved the ability to identify individuals from their dental records.[8]

d) Archaeological Excavation Methods:

Excavation Techniques: How archaeological sites are excavated and processed has evolved significantly. Modern techniques are more careful and systematic, reducing the risk of damage to skeletal remains compared to historical methods.[9]

e) Documentation and Record-Keeping:

Data Preservation: Advances in data recording and preservation have made it possible to store and analyse information about skeletal remains in ways that were not available in the past. This allows for more extensive comparisons and research.

f) Environmental Changes:

Urbanization: The growth of urban areas and changes in land use can affect the preservation of archaeological sites. Urban development may destroy or bury sites, making the recovery of skeletal remains more challenging.[10]

g) Natural Disasters:

Impact Events: Rare but significant events like volcanic eruptions, tsunamis, or earthquakes can alter landscapes and impact the preservation of remains in a given region.

h) Chemical Changes:

Pollution: Industrialization and pollution can alter the chemical composition of soils, affecting the preservation of skeletal remains and potentially leading to changes in taphonomic processes.

i) Disease Patterns:

Epidemics: The prevalence and impact of diseases on human populations have varied over time. Epidemics can leave distinct markers on skeletal remains and may have different geographic patterns in different time periods.

j) Genetic analysis:

Advances in ancient DNA analysis have provided a new dimension to understanding the geographic origins and population movements of ancient individuals. This can complement traditional forensic odontology methods.[11]

In summary, temporal changes in geographic variation in bioarchaeology from a forensic odontological aspect reflect the dynamic nature of the field. As technology, methods, and environmental conditions evolve, researchers and forensic experts must adapt their approaches to accurately analyse and interpret skeletal remains from different historical periods. Additionally, advances in interdisciplinary research and collaboration can enhance our understanding of how taphonomic processes and geographic factors have changed over time.

3. Taphonomic Factors

Taphonomy is the study of post-mortem processes that affect organisms, including humans, after they die. In bioarchaeology and forensic odontology, taphonomic factors play a crucial role in understanding the preservation and interpretation of skeletal remains. Geographic variation in taphonomic processes can significantly impact the analysis of these remains. Here's how taphonomy influences bioarchaeology and forensic odontology, with a focus on geographic variation:

a) Environmental Factors: Different environments, such as deserts, forests, wetlands, or urban settings, have unique taphonomic processes. For example, arid environments may lead to desiccation and mummification, preserving skeletal elements differently than humid environments, where decomposition and decay are more rapid.[12]

b) Climate: Climate, including temperature and humidity, can affect the rate of decomposition and bone degradation. In colder regions, skeletal remains may be preserved better due to slower decomposition rates, while in tropical regions, decay can be rapid, leaving only scattered bones.[12]

c) Soil Composition: The type of soil in a particular geographic area can have a profound impact on bone preservation. Acidic soils tend to dissolve bone minerals, while alkaline or calcareous soils may enhance preservation.

d) Biological Factors: The presence of scavengers, such as insects, rodents, or larger animals, can scatter and damage skeletal remains. Predation marks, gnaw marks, and bone breakage patterns can vary by geographic location.

e) Cultural Practices: Human activities, including burial practices and funerary customs, differ across regions and can affect the preservation of remains. For example, some cultures practice cremation, which leaves behind very different archaeological evidence compared to inhumation.

f) Natural Disasters: Events like floods, landslides, earthquakes, or volcanic eruptions can bury, displace, or damage skeletal remains, and the likelihood and impact of these events vary by region.

g) Time Since Death: The length of time since death can vary greatly depending on when and where an individual died. This affects the stage of decomposition and the likelihood of scavenger activity.

From a forensic Odontological perspective, Taphonomic factors can influence the state of dental remains and their potential for identification. Teeth are highly durable and can survive many Taphonomic processes better than other skeletal elements. However, factors like soil acidity, moisture, and temperature can still affect the condition of teeth and dental records.

In both Bioarchaeology and forensic odontology, understanding the regional Taphonomic context is crucial for accurate interpretation and identification. Researchers and forensic experts must consider the specific Taphonomic processes and conditions of the geographic area in which they are working to make meaningful conclusions about skeletal remains or dental records. This contextual knowledge helps ensure that Bioarchaeological and forensic analysis are as accurate and informative as possible.[13]

4. Climate And Environment

Most of the Consistently observable skeletal differences between human populations, e.g., Stature, limb proportions, facial characteristics, and the like, are the result of climatic adaptations to the environments in which these populations originally evolved. Consequently, equatorial populations are expected to exhibit bodies with greater surface area, characterized by features such as long limbs, tall stature, elongated heads, and so forth. Conversely, populations adapted to cold climates, like Northeast Asians and other Arctic indigenous peoples, tend to possess rounded bodies on shorter skeletal frames, with less prominent extremities, rounded skulls, and flatter facial profiles, aiding in heat retention. Numerous other nonmetric variations can also be associated with populations as allele frequencies for those traits increase as a result of gene sharing within circumscribed geographical area. Physical anthropologists have described These diagnostic skeletal variations and their incidence within many Populations, subgroups, and admixed groups elsewhere [14-17]

5. Disease patterns

Conditions and ailments affecting the endocrine system can either delay or hasten skeletal, dental, and sexual development. It is advisable for odontologists to refrain from conducting age assessments on individuals diagnosed with endocrine disorders.

6. Dental Traits And Ancestors

In contemporary anthropology, the term "race" has largely been replaced by "biotype," "population," or "ancestry." These terms aim to reflect the genetic relationship between an individual and a group sharing similar genes. Through close gene sharing, characterized by breeding within proximity, distinct average features may emerge, placing individuals within broader, albeit informally recognized groups. Evaluating cases involving admixture, such as Negro plus Mexican Indian (Negroindio) or Amerindian plus French/European plus Negro (Creole), can be particularly challenging. Similar to sex, population characteristics are influenced by natural selection. Human populations exhibit observable skeletal variations due to climatic adaptations. Equatorial populations tend to have bodies with high surface area (long legs, arms, tall stature), while arctic populations have rounded bodies for heat retention. Nonmetric variations in allele frequencies are associated with specific geographical areas. Ancestry assignment involves statistical comparisons of measurements from unknown remains with known population data. Limb proportion indices and nonmetric traits aid in the analysis. Skull structures are crucial for attributing ancestry. The challenge lies in translating complex anatomical and statistical findings into practical classifications.

7. Dental Pathology And Geography Indicators

The dental evidence is compared with the ante-mortem records available to the dentists for identification of the deceased in DVI.[15]

These comparisons can be achieved by using dental radiographs and dental records available with the dentists. Sometimes, the dental evidence can be compared with the ante-mortem photographs available with the family members usually showing the anterior teeth.[17] Dental records use the universal dental numbering system and provide extensive information about an individual's teeth. Forensic dental comparison entails assessing specific features of the teeth known as individualizing characteristics, including dental fillings, extractions, surface structure/root configuration, adjacent teeth, crowding, diastema, spacing, orientation abnormalities (twisted/tilted teeth, rotations, transpositions), missing or extra teeth, supernumerary cusps, as well as other anomalies and developmental disturbances. Tooth morphology variation remains a significant focus for dental anthropologists and forensic odontologists. This variation aids in classifying population groups and identifying individuals during forensic examinations. Dental anomalies and variations encompass several aspects:

a) Disturbances in tooth size, including microdontia (smaller than normal teeth) and macrodontia (larger than normal teeth).
b) Disturbances in the number of teeth, such as anodontia (congenital absence of teeth), polyodontia or hyperdontia (extra teeth).
c) Disturbances in tooth eruption, such as impacted teeth (failed eruption, remaining d. buried in the alveolar bone) and ectopic eruption (blocked by adjacent or misplaced orthodontic bands).
d) Disturbances in tooth shape, including dilaceration, flexion (severe bend in the tooth's long axis), taurodontism (abnormally long pulp chamber and short roots), and supernumerary cusps like Carabelli's cusp, talon cusp, and peg-shaped lateral incisors.
e) Variations in the number of tooth roots, shovel-shaped incisors.
f) Other disturbances, such as enamel pearls (small nodules of enamel near the cemento-enamel junction), Hutchinson's incisors or mulberry molars, winged incisors, enamel hypoplasia (caused by severe sickness or nutritional deprivation), and enamel imperfecta (amelogenesis imperfecta).

At times, the occlusion type between the mandibular and maxillary teeth aids in identification, with occlusions typically falling into three categories: overbite or deep overbite, normal bite, and underbite. These dental anomalies and variations facilitate the comparison of ante-mortem and post-mortem records to confirm individual identity.[16] They establish the uniqueness and identity of the deceased during forensic examinations, akin to DNA profiling and morphological fingerprints. However, without ante-mortem dental records or the ability to compare post-mortem records, these characteristics may not be particularly helpful to investigators. Nonetheless, available dental records can still assist investigators in narrowing down information by estimating the deceased's biological profile, including age, sex, and race.

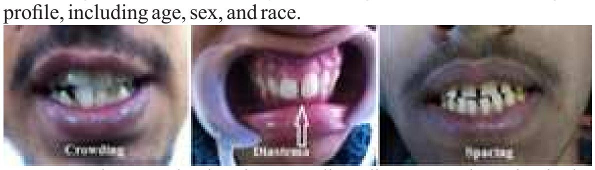

Figure 1- Photographs showing crowding, diastema and spacing in the teeth.

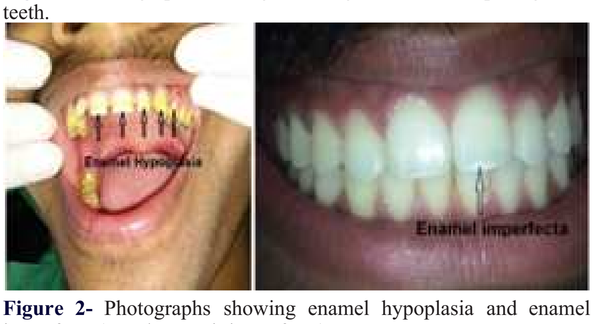

Figure 2- Photographs showing enamel hypoplasia and enamel imperfecta (Amelogenesis imperfecta).

Figure 3- Photographs showing transposition of canine with lateral incisors and supernumerary premolar.

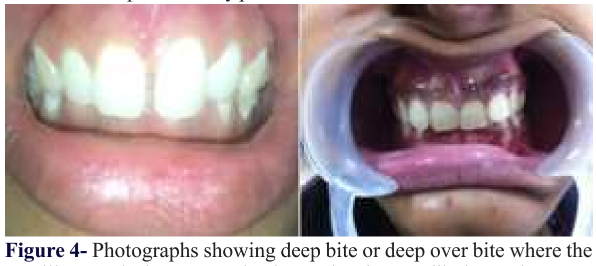

Figure 4- Photographs showing deep bite or deep over bite where the maxillary teeth almost completely overlap the mandibular teeth

Source- Goldman A.D. The scope of forensic dentistry. In: Cottone J.A., Standish S.M., editors. Outline of Forensic Dentistry. Chicago: Yearbook Medical Publishers; 1982. pp. 15–19.

8. Bite Mark And Geographic Source

Analysis of bite marks plays an important role in personal identification in forensic casework. Bite marks can be recorded in violent crimes such as sexual offences, homicides, child abuse cases, and during sports events. The arrangement, size and alignment of human teeth are individualistic to each person. Teeth, acting as tools leave recognizable marks depending on tooth arrangement, malocclusion, habits, occupation, tooth fracture, and missing or extra teeth. Bite mark identification is based on the individuality of a dentition, which is used to match a bite mark to a suspect. Bite marks are often considered as valuable alternative to fingerprinting and DNA identification in forensic examinations. The present review describes the classification, characteristics, mechanism of production, and appearance of bite mark injuries, collection of evidence, comparison techniques, and technical aids in the analysis of the bite marks.[20]

9. Age And Dental Development

Tissues, organs, and systems mature at different rates. Some undergo renewal throughout life, while others decline due to wear, disease, nutrition, and trauma. Determining the chronological age of a decedent at the time of death involves methods using hard tissues. Skeletal assessments of age correlate well with dental techniques up to around fifteen or sixteen years of age. Full maturation of the skeleton takes longer than the dentition. The dentition (teeth) is more reliable for estimating age. Diet, disease, trauma, and oral hygiene affect age determination. Sex and population membership influence development rates. A general approach to determination of age follows:

Fetal period: Estimation of fetal developmental age assumes forensic importance in most jurisdictions because it is usually an indicator of viability. In instances of criminal death of a pregnant individual courts may decide whether to prosecute more than one homicide depending upon the age (i.e., viability) of the fetus. Knowing the age of a discovered fetus may also assist in matters of identification. Usually, diaphyseal lengths may be used in various algorithms to estimate crown-rump length, which may then be translated into lunar age. The timing of appearance of primary and some secondary ossification centres are also of use. Several sources give good accounts of the statistical reliability of various bones and measurements for both gross and radiographic fetal age determination,.

Birth to sixteen years: As noted, dental and osteological age should correlate well within this developmental interval. In recent years anthropologists and odontologists have become increasingly aware of differences in rates of skeletal and dental maturation among various populations, and have begun to apply adjustments to their age estimates accordingly. Radiological age standards have proved useful, especially for the hand and wrist, from early childhood to late adolescence; however, these skeletal components are among the first to be removed by scavengers and are often unavailable.

Sixteen to thirty years: As attachment of primary and secondary ossification centres occurs throughout the skeleton, attention turns to the completion of fusion of these centres. [21]

CONCLUSION

In essence, the study of regional differences in bioarchaeology and forensic dentistry is fundamental to both disciplines. These variations offer key insights into the diverse life histories and backgrounds of people across various areas, contributing to our grasp of historical populations and supporting the forensic identification process and criminal probes. With ongoing advancements in these scientific domains, our comprehension of the impact of geographic diversity is expected to grow more detailed and all-encompassing.

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