Xournals

Academic Journal of Anthropologial Studies

ISSN: 2581-4966 | Volume 06 | Issue 01 | April-2023

Age-Related Trabecular Bone Changes in Pubic and Auricular Surface of the Ileum in Post-Mortem CT

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Available online at: www.xournals.com

Received 18th January 2023 | Revised 10th February 2023 | Accepted 16th March 2023

Abstract:

In various domains, including Forensic Anthropology, Archeology, and Medicolegal Investigations - accurate identification of someone's age remains pivotal to carrying out legal proceedings or upholding humanitarian objectives. This review paper unveils a scientific method of studying Post Mortem Computed Tomography (CT) scans to achieve forensically precise age estimations by closely analyzing trabecular bone changes within pelvic bones. Throughout a person's existence, the trabecular bone, which is made up of connected bony struts within cancellous bone, changes morphologically. Advanced imaging techniques can be used to see and measure these age-related changes. Alongside detailing the underlying principles involved in using CT scans to assess someone's age we also explore potential challenges that may arise from employing this method. Furthermore, we examine the validity and limitations associated with analyzing trabecular bone changes within pelvic bones ascertaining one's true age - ultimately showcasing its critical impact on forensic activities.

Keywords: *Trabecular bone, Pelvic bone, Forensic age estimation, Post-mortem CT*

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Introduction

A key component of medico-legal investigations is forensic age estimate, which enables the assessment of an individual's chronological age based on biological indicators. These estimates are crucial in a variety of situations, such as the identification of unknown people, determining the age of live people whose birth documents are questionable, and offering significant evidence in criminal investigations. Given its non-invasive nature and capacity to provide precise three-dimensional images of skeletal structures, post-mortem computed tomography (CT) has drawn a lot of interest among the different techniques used for forensic age estimates. A particularly promising area of research for age estimate is the trabecular bone alterations of the pelvic bone. The spongy, lattice-like structure which composes up the inside of bones and is in charge of supplying support and strength is referred to as the trabecular bone. The trabecular bone gradually changes as we become older, including changes to its density, structure, and shape. Numerous skeletal components, including the pelvis, have shown these age-related alterations in trabecular bone, which have been connected to age-related illnesses including osteoporosis **(Villa *et al.*, 2013).**

Literature Review

A forensic anthropologist has to generate a biological profile of the victim based on skeletal details seen when evaluating the remains in order to identify a person. An estimation of the four class characteristics known as age, sex, stature, and geographic population affinity that are determined from skeletal features is referred to as a biological profile **(Márquez-Grant, 2017).**

There are different ways of skeletal age assessment in the field, but macroscopic inspection of morphological changes in characteristics on the bone surface is the most common. The majority of bone surfaces that are used to estimate age are joints, where two surfaces rub against one another while the body moves. As a result of this movement and the aging-related deterioration of the bone surface, a morphological metamorphosis eventually takes place **(Altes, 2018).**

Macroscopic approaches are less expensive because they only need skeletal remains, an understanding of human anatomy, and the right technique. However, because to the reliance on the examiner, macroscopic approaches do have a tendency to have a higher rate of intraobserver error**.** Radiology, microscopy, radiocarbon analysis, and DNA analysis are further techniques that can be used to estimate the age of skeletal remains**.**

The pubic symphysis and the auricular surface of the ilium are the two most often used sites for macroscopic age estimates in adult skeletal remains**.** Occasionally, the vertebral column, acetabulum, sternal ends of the ribs, cranial sutures, and radiographic imaging of bone density have also been employed **(Işcan, 2017).** In forensic or physical anthropology, the pubic symphysis is the most often used and thoroughly researched bone age indication**.** The pubic symphysis and auricular surface of the ilium are usually used because they are resistant to degradation after the person has passed away. Even among prehistoric populations, the auricular surface of the ilium has a particularly high survival and finding rate, making it a highly advantageous surface option **(Priya, 2018).** The basic profile of a person can be provided by forensic anthropological studies, which may help to reduce the number of possible identities. Here, more advanced and contemporary methods of identification, including DNA, can be utilized to verify identity **(Flanagan *et al.*, 2019).**

- **Age Estimation Techniques Using the Ilium's Auricular Surface**

A number of techniques exist for determining age from adult auricular surfaces of the ilium. On the macroscopic age-related evolution of feature degradation, the following are all based. A phase-based approach focuses on categorizing a surface into a certain age phase after a thorough analysis of the surface **(Lovejoy *et al.*, 2017).** The level of degeneration existing for each feature is represented by individual numerical values or scores in a composite or component-based technique.

Following the combination of these individual scores, a total score and an age estimate are produced **(Buckberry *et al.*, 2017).** Igarashi et al. created a binary strategy based on the presence or absence of a set of age-indicating variables and multiple regression analysis. The multifactorial method, which combines various surface estimates with statistical analysis to get a more accurate age estimate, is another less popular technique for calculating age.

Long after Todd's invention of the pubic symphysis method in 1921, Sashin initially noted the progressive morphological changes of the auricular surface of the ilium in 1930 **(Lovejoy *et al.*, 2017)** and later attributed them to aging. Following this, Lovejoy et al**.** published the first phase-based technique, and Buckberry & Chamberlain released the improved

composite-based method. In the end, Osborne, Simmons, and Nawrocki modified the original technique to create another phase-based age estimation technique **(Flanagan *et al.*, 2019).**

Trabecular Bone Analysis

The trabecular bone may quickly adjust to mechanical loading and refine its shape to support heavy loads with the least amount of tissue. Fractures frequently happen in skeletal structures like the vertebrae that are primarily made of trabecular bone. Understanding how to photograph and measure the trabecular bone's structure is consequently crucial. This may be done on specimens using microscopy and micro-CT, and there is good agreement between the two techniques. **(www.diva-portal.org**) The following crucial structure characteristics should be measured:

- Trabecular nodes; are the number of trabecular intersections per mm^3
- Trabecular termini; are the number of free ends of trabeculae per mm^3
- Trabecular separation; is the thickness of the spaces between the trabeculae in mm
- Trabecular spacing; is the distance between the midlines of the trabeculae in mm
- Trabecular number; are the number of trabeculae in 1/mm
- Trabecular thickness; is the thickness of the trabecular structures in mm
- Bone volume over total volume (BV/TV); is measured by dividing the number of voxels classified as bone by the total number of voxels in the volume.

Computed Tomography – CT

Computed tomography is a diagnostic imaging method that produces cross-sectional grey-scale images of the item by sending fan-shaped X-rays across it. The X-ray source revolves around the target while the X-rays it produces pass through the target, such as the human body. A detector will track the X-rays that pass the object and measure them. For each rotation, there are various projections. The amount of radiation that passed through the tissue and into the detector as represented by the digital values provided by the detector will be examined using sophisticated reconstruction methods that call for powerful computer systems. These intricate mathematical calculations make it possible to distinguish between tissues and give them distinct CT- or Hounsfield Unit (HU)-values as a result of variations in attenuation in tissues. The measured attenuation coefficients undergo a linear modification to yield the HU values. Air has an HU-value of -1000, and distilled water has a radio density of 0 at standard temperature and pressure (STP) **(www.diva-portal.org).**

Result and Conclusion

Forensic age estimation using post-mortem CT based on trabecular bone alterations in the pelvic bone constitutes a significant improvement in the field of forensic anthropology and offers useful tools for determining an individual's age. To improve these techniques and expand their application to various populations and forensic contexts, additional study and validation are required. But for forensic investigations around the world, the potential advantages of non-invasive and precise age assessment utilizing post-mortem CT hold enormous promise.

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