H3 The Use of Micro-Computed Tomography to Determine Volumetric Shrinkage Trends of Thermally Damaged Bone

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After attending this presentation, attendees will gain an understanding of the potential of micro-Computed Tomography for the advancement of forensic anthropological research as a nondestructive means of measuring changes in the bones' micro-architecture, volume, and stereology.

This presentation will impact the forensic science community by demonstrating the usage of micro-CT to accurately document and quantify shrinkage as well as morphological changes of heat-exposed bone, allowing a more in-depth comprehension of bone's structural changes in response to heat and its implications for techniques of biological profile estimation.

In recent years, micro-CT has become an emerging practice in the forensic sciences. Its application in forensic anthropology has, however, to date been minimal despite its undeniable potential. Due to the high signal contrast between bone and soft tissue and its significantly higher spatial resolution than standard clinical CTs, the technology is already finding frequent use in medical pre-clinical investigations. In forensic settings, micro-CT has been utilized to determine class and individual characteristics of tool marks on bone, and its application toward the visualization of age-related changes of bone landmarks such as the pubis or sternal rib ends, allowing for a quantification of parameters such as ridge depth and surface areas without the removal of soft tissues, has been discussed in the literature.[1]

The present study explores the usage of micro-CT to assess and quantify changes in the volume and microstructure undergone by bone subjected to heating. The phenomenon of thermally induced shrinkage and the implications for forensic anthropology, particularly the effect on metrical techniques such as size and stature estimation, have been discussed and investigated by a number of researchers over the past decade. Studies have reported vast discrepancies in bone shrinkage, ranging between 1% and 27% depending on factors such as the experimental conditions, the skeletal element and its compact to spongy bone ratio, mineral composition, and fragment size.[2] However, all of these observations are based on manual caliper measurements, not taking into account the three-dimensional volumetric shrinkage and changes in bone micro-architecture and stereology which would allow for a more accurate determination of absolute shrinkage. To date there has solely been one study carried out using micro-CT to investigate the heat-induced shrinkage of dental tissues, showing the feasibility of this approach.[3]

Research was carried out using fresh de-fleshed sheep ribs (*Ovis aries*) cut into 0.5cm - large sections and burned in an ashing furnace in triplicates at temperatures between 400°C (the average temperature of a camp fire) and 1000°C (average temperature of a crematorium) in 100°C increments for 45 minutes. All samples were scanned pre- and post- burning using a SkyScan™ 1172 micro-CT scanner at 13.59µm resolution using 49kV voltage, 120µA current and a 0.5mm aluminum filter. The resulting files were subsequently reconstructed using the SkyScan's™ NSRECON package utilizing a uniform attenuation coefficient.

Pearson's correlation coefficient shows a clear correlation between temperature and degree of shrinkage at the 0.01 level (R^2= 0.905). Average volumetric shrinkage ranged from 14.0% (at 400°C) to 45.5% (at 1000°C), which corresponds to 5.8% to 12.7% shrinkage in the diameter. ANOVA with post hoc LSD test showed no significant difference in shrinkage at temperatures up to 600°C ($p>0.05$). An increase in shrinkage was found in the 700°C and 80°C samples ($p<0.05$). Bones burnt at temperatures of 900°C and 1,000°C both showed significantly higher shrinkage than any other temperature groups ($p<0.05$). Further analysis of the dependency of shrinkage on factors such as fragment size, compact thickness and the compact-to-spongy bone ratio are planned.

The findings of this research signify the vast potential of micro-CT in forensic anthropological research on the effects of factors such as diagenesis or burning on the bones density, morphology and micro-architecture, a comprehensive understanding of which is crucial for the correct interpretation of biological profile and taphonomy of skeletal remains in a forensic context.

References:

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Micro-CT, Cremains, Fire Victim Identification

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