In order to compare head drops versus the entrapped impacts, 31 porcine specimens aged 2-17 days were used. To produce the necessary impact energy, the head was attached to a drop tower trolley, which was raised to the necessary drop height. In the experiments a solenoid disengaged, allowing the trolley to fall freely. Upon impact, the head was disengaged from the trolley allowing it to impact a rigid aluminum interface once, by using an electromagnetic solenoid to catch the head after impact. The impact energy levels for various aged specimens in the current study were matched to the energy levels documented in Powell et al. for the entrapped heads. The fracture patterns were compared between experiments using a GIS image-analysis approach, as previously described by Marean *et al.*[3,4]

Results from these controlled head drop experiments demonstrated that the impact duration was significantly shorter than for the entrapped head experiments of Powell et al. (*p-value* < 0.001), however the peak impact force data was not different at each specimen.[3] There was significantly less skull fracture at each age for the free fall experiments than for the entrapped heads (*p-value* < 0.001). GIS fracture pattern results demonstrated that fracture initiation was located primarily along the anterior parietal bone in all free fall specimens. A simplified, theoretical model analysis of each experiment, using the finite element approach, showed that large tensile stresses develop around the periphery of the entrapped head, near the epoxy constraint, that likely produced extensive fractures remote to the site of impact. The tensile stresses in the head model were lower and located more near the impact site in free fall experiments.

While further research is necessary in order to define any potential relationships between the infant porcine model and the infant human, these results showed that head entrapment provides a significant stress riser that enhances the potential for cranial bone fracture compared to an equal amount of energy to a freely falling head impacting a rigid surface.

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Child Abuse, Fracture Patterns, Bone Biomechanics

H83 Geometric Morphometric Analyzes From Dental Orthopantogram Images: A Regional Anatomical Analysis of Sexual Dimorphism in the Adult Mandible

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After attending this presentation, attendees will have a better understanding of a new method of sex assessment through the analysis of clinical panoramic X-ray images.

This presentation will impact the forensic science community by introducing a novel method of sex determination following a skull assessment.

The human mandible has routinely been utilized in forensic assessment of age at death, sex determination and biological affinity. However, such studies have generally utilized conventional assessments of size and shape variables, and as such fail to record the true nature of shape differences due to dimorphism in this functional skeletal element. The research here presented utilizes geometric morphometric techniques to investigate and quantify shape and size variation in the morphology of the mandibular corpus and ascending ramus, and consequently the potential for forensic human identification. The results of a novel morphometric study using clinical panoramic scanning x-radiography to study the extent of morphological variation within a modern Italian sample population are presented.

Clinical digital orthopantogram images (OPG) were acquired of the upper and lower jaws of 50 male and 50 female participants. Ten type I and type II 2D landmarks were applied to the symphysis, and condylar and coronoid processes. One hundred equidistant semi-landmarks were established along the inferior border of the corpus, and the posterior border of the ascending ramus. The resulting landmark configurations (n 100) were subjected to Generaliszd Procrustes Analysis (GPA) with Full Tangent Space Projection. Principal Components Analysis (PCA) was applied in order to assess population variation. Factor loadings were subject to Canonical Variates Analysis with stepwise and leave-one-out classification in order to assess the effects of sexual dimorphism on mandibular shape. The results showed individuals to be correctly classified for sex in 89.6% of cases, (males were correctly classified in 90.1% of cases, and females in 85.6%).

Analyzes of the mandible were subsequently broken down into anatomical regions based on the mandibular body, the bony processes and the ascending ramus in order to investigate regional functional differences in the expression of dimorphism in mandible. A partial least squares (2-block PLS) method was further applied, in order to examine patterns of covariation between shape variables and the exploration of patterns of functional modularity. Most interestingly the results indicate the greatest level of individual and sex-specific variation is found in the shape-curve and pattern of the inferior corpus, in contrast to that of ramal flexure. Stepwise permutation tests and analyzes of regional covariation indicate functional coupling, with a moderate degree of modular integration between the corporal and ramal regions suggesting that functional ties between the units are correlated in influencing sex-based morphological trait expression between anatomical regions, indicating that the geometric relationship between the mandibular corpus and the ascending ramus offers significant power for forensic identification purposes. Consequently such units may be studied together or in isolation, and this may allow for the development of identification criteria based on modular unit shape variables which may be applicable for both whole specimens and fragmented remains depending on the forensic situation. Overall the results are strongly significant and suggest that both dependently and independently that the

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shape relationship between the mandibular corpus and the ascending ramus offers significant power for forensic identification purposes. Of particular interest is that inferior corpus border shape offers significant discriminating potential in the assessment of sex, with the effects of allometry being strongly implicated. These and other implications of the shape analysis will be discussed.

Sex Assessment, Geometric Morphometrics, Forensic Anthropology

H84 A Comparison of Age-Related Macroscopic Traits of the Ilium and Sacrum

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After attending the presentation, attendees will have a better understanding of age-related traits of the auricular surfaces of the ilium and sacrum in terms of age-at-death indicators

This presentation will impact the forensic science community by demonstrating potential differences in the development of three macroscopic traits of the auricular surfaces of the sacrum and ilium as well as the potential significance for estimating age-at-death from these structures.

Accurate age-at-death estimation from human skeletal remains is critical for establishing a comprehensive and forensically significant biological profile of an unknown individual, which in turn facilitates the victim identification process. While many regions of the human skeleton have methods to facilitate adult age estimation, the auricular joint of the pelvis presents a unique structure to compare similar traits across the sacrum and ilium. Interestingly, while both the sacrum (Passalacqua) and the ilium (Lovejoy et al., Buckberry and Chamberlain, Osborne, among others) have age-at-death estimation methods, there has been little work relating the adult degenerative changes which occur on the paired auricular surfaces.[1-4] In fact, Lovejoy et al. state: "The sacral [auricular surface]...does not reflect the age changes described below [in regard to their method of scoring the ilium] and cannot be used to determine age."[2] This presentation tests that assertion.

The primary aim of this study was to assess three degenerative traits (apical changes, microporosity and macroporosity) found on both the sacrum and ilium auricular surfaces and compare the timing of appearance for each trait across the auricular joint. Paired ilia and sacra from the Hamann-Todd (n=380) and Bass (n=234) collections comprise the samples used in this study. Individuals from the Hamann-Todd collection consist of males and females, mainly of African and European ancestry, ranging in age-at-death from 10 to 96 years and individuals from the Bass collection consist of males and females of European ancestry, ranging in age-at-death from 16 to 97 years. Previous research (Lovejoy et al.; Passalacqua) found no significant sex or ancestry differences in regard to age-related changes of the ilium or sacrum.[2,1]

These traits develop over a continuum and each morphological character was scored according to multiple trait variants as described in Passalacqua and Buckberry and Chamberlain.[1,3] However, in order to limit observer error and deal with discrepancies in method scoring procedures, these traits were re-scored on a presence or absence scale (1 and 0, respectively). A Kruskal-Wallis test was then used to assess differences in presence and absence of these traits between the ilium and sacrum. Results suggest that macroporosity appears earlier and more often in the ilium (mean age = 50.65) than the sacrum (mean age = 53.8 years, $\chi^2 = 82.926$, df = 1, *p-value* = 0.000). However, apical change ($\chi^2 = 2.145$, df = 1, *p-value* = 0.143) and microporosity ($\chi^2 = .464$, df = 1, *p-value* = 0.496) show no significant difference in presence or absence frequency.

While Lovejoy and colleagues may have failed to recognize corresponding traits appearing on the sacral auricular surface, our results suggest similar ages of onset for microporosity and apical changes. However, much of the auricular changes of the ilium are more subtlety expressed on the sacrum, likely as a function of thicker cartilage covering the sacral auricular surface (Schunke).[5] While the etiology of macroporosity on the auricular surfaces is unclear, overall it was found in much greater frequency on the auricular surface of the ilium. This could be a function of the degeneration of the ilium's cartilage due to the thinner cartilage covering that portion of the auricular joint; however, further research is required to investigate the cause.

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Forensic Anthropology, Age-at-Death Estimation, Auricular Surface

H85 Metric and Non-Metric Assessments of Sex: Accuracy, Correlation, and Corroboration

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After attending this presentation, attendees will understand the reliability of non-metric methods, as well as their correlation with metric methods, which are commonly employed in biological profile estimation for unknown individuals.

This study will impact the forensic science and anthropology community by demonstrating the relationship between both types of methods, as well as their relative accuracies, in sex estimation from a forensic context.

Sex estimation is a vital component of the biological profile estimation in forensic identification of skeletonized or badly decomposed unknown individuals. While the forensic anthropological community is moving toward the increased use of metric methods, non-metric methods continue to be routinely employed because of their relative ease of use, their perceived reliability, and because they are frequently "passed-down-knowledge." Because of these factors, non-metric methods are often still utilized for biological profile estimation, in conjunction with metric assessments, particularly with the human skull and pelvis. The skull has historically been the most studied portion of the skeleton for both ancestral and sex related differences, while the pelvis, specifically the innominates, is widely regarded as the greatest indicator of sex due to the dimorphism related to childbirth in females.

Non-metric and metric data were collected from all forensic cases conducted from 2009 to present at the Department of Applied Forensic Sciences at Mercyhurst College in Erie, PA. The non-metric methods utilized for sex estimation include: (1) the Walker method for sex estimation of the crania using the expressions of the supra-orbital ridge, the mastoid processes, the mental eminence, the nuchal crest, and the supra-orbital margin of the orbits; and, (2) the Klales *et al.* (in press) method for estimating sex using ordinal scoring and expressions of the subpubic concavity, the medial aspect of the ischio-pubic ramus, and the ventral arc in the pubic bone as modified from the Phenice method.[1-3] In addition to

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