H13 Fetal Sexual Dimorphism of the Ilium: A 3D Geometric Morphometric Approach

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After attending this presentation, attendees will be familiarized with the use of 3D geometric morphometric measurements for the study of sexual fetal dimorphism.

This presentation will impact the forensic science community by demonstrating feasibility of outline analysis for immature forms.

This study aims to look for a sexual fetal dimorphism, using 3D geometric morphometric measurements, by applying Elliptic Fourier analysis (EFA) based on the study of 93 European fetal iliac bones aged between 21 weeks and 40 weeks from amenorrhea (WA), recorded by multi-slice computed tomography (MSCT), and 3D reconstructions. This study demonstrates the feasibility of outline analysis, especially for immature forms; however, there was no sexual dimorphism established by this study.

The evidence of sexual dimorphism in human adults has been established and studied for decades. Therefore, the information for fetuses is not well known, with few studies and contradictory results. Ninety-three French fetal iliac bones aged between 21 weeks and 40 weeks from amenorrhea(WA), coming from the anatomic collection of Marseille Hospital, were recorded by multi-slice computed tomography (MSCT), and 3D reconstructions. The 3D geometric morphometric analysis was based on outline analysis. EFA was used because of the immature morphology and the difficulty of landmark positioning. Reconstructions allow shape descriptions for each harmonic. Principal Component analysis (PCA) was performed separately for each age group (cut off at 30 WA).

According to the literature, the collection was divided into two age groups, with a limit at 30 WA. Both groups are well balanced (sex ratio respectively about 0.86 and 0.94). The first ten Principal Components axes represent 96% of the global variability, with harmonics or with amplitudes study. To allow best choice about the most discriminant principal component axes, PCA axes were selected using the most important eigenvalues (PC1- PC2), then by Wilks' Lambda analysis, and finally by applying Jolliffe eigenvalue threshold of 0.7 on the most discriminant PC axes with Wilk's test. In order to describe the best methodology in the Elliptic Fourier outline analysis, PCA was applied on amplitudes and harmonic coefficients derived from the Fourier series.

The accuracy of the reconstructions increased with the number of harmonics. The simultaneous analysis of the step-by-step reconstructions and the harmonics ellipses demonstrates that harmonics presenting the greatest amplitudes (magnitudes) and greatest axis ratios have the greatest morphologic contributions, which can be related to anatomic features. The convergence between the reconstructed outlines and the original outline by the use of an increasing number of harmonics can be easily appreciated visually, and can be quantified by the fit index, which is the sum of the squared distances between the reconstructed points and the original outline. The major morphologic characteristics were mainly described by the first seven harmonics presenting the greatest amplitudes. Finer features were described by harmonics of higher order. The iliac crest was the first to be described in step by step reconstruction from the second harmonic. The ischial tuberosity appeared as a positive relief around the fourth harmonic and its asymmetry around the fifth. The greater sciatic notch is described by the fifth harmonic. Its real depth and its asymmetric aspect appeared with the seventh harmonic. A perfect description is acquired around the seventh. After the eighth harmonic, there are no visible significant differences between shapes described by each one.

The best graphical representations in terms of sexual dimorphism were different between the age groups. But, these representations were not so easy to interpret, because of the absence of clear discrimination between female and male groups, regardless of the PCA selected. The overlap between age groups was too large to allow a sexual discrimination.

For fetuses between 21 and 29 WA there was no clear discrimination between age groups, regardless of which method was used (PC1-PC2, PC1-PC21 and PC1-PC11). The study for oldest fetuses leads to the same findings: big overlap and no clear discrimination between sex groups.

While various pelvic indicators showed marked sexual dimorphism in adults, there are no comparable levels of dimorphism in subadults and especially in fetuses. Several studies tried to answer questions asked by anthropologists and forensic physicians. Even if a significant sexual dimorphism in 2D elliptical Fourier analysis of the iliac outline was revealed, it was not possible to localize the source of this dimorphism. Computer-assisted image analysis allowed an automatic quantification of the outlines shape. It presents many advantages like greater objectivity and reproducibility, greater rapidity, and facilitation of measurements traditionally impossible to determine directly. Unlike the adult hip bone,

where landmarks are relatively simple to define, the fetal ilium is a smooth continuous form with few or no landmarks. These characteristics make a classic Procrustes analysis unreliable. Summary forms need another type of morphometric study, which overcomes reference points. For cases where landmarks are difficult to obtain, outline analysis is the preferred option for analyzing shape. Elliptic Fourier analysis (EFA) used in this study is Fourier series for closed outlines. EFA is a Fourier method that interpolates the outline to get a large number of points. Many shapes can be described by the amplitudes of only few first harmonics. This method has been tested extensively in the literature. It has its applications in many fields, like biology, paleobiology, palaeontology, zoology, and biological anthropology, with different methods such as harmonic coefficients or amplitudes. Data agree that there are no significant differences between Fourier analysis and analyzes using landmarks for simple shapes, or shapes with reproducible point references. This study is the first to apply outline analysis using Elliptic Fourier analysis on shapes derived from immature remains. 3D was used because of its better accuracy in outline description, with homogenous age and sex groups. Even if a description was possible for the different anatomic regions of the ilium by the step-by-step reconstructions, there was no difference between sex groups demonstrated by these methods on the population. The intraobserver variability has been tested and was less than 5%, highlighting good reproducibility of the outline delimitation.

The question of the fetal sexual dimorphism is quite difficult to resolve. In immature bones, the relationship with age and the difficulty to use reproductive homologous points are factors of limitation of the geometric morphometric studies like Procrustes or eigenshape analysis. Furthermore, the small size of age and sex group and the possible poorly marked dimorphism need more investigation, with larger samples in order to assess the absence of a sexual dimorphism.

Outline Analysis, Sexual Dimorphism, Ilium

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