Relative Orbitonasal Overlap in African Great Apes and Humans
Quantified by the Automatic Determination of
Horizontal and Vertical Lines of Reference

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ABSTRACT. The relative positions of the orbital and nasal openings in African apes and humans were studied by a new methodological approach based on the automatic determination, by image analysis techniques, of horizontal and vertical lines of reference. The material used consisted of Gorilla gorilla (38 males and 20 females), Pan troglodytes (19 males and 13 females), and modern Homo sapiens (51 males and 41 females). This allowed the relative positions of the orbital and nasal openings to be quantified by the determination of medio-lateral and vertical orbitonasal indices of overlap. In all the species studied, a medio-lateral orbitonasal overlap was systematically observed. This indicates that nasal breadth is always larger than interorbital distance. Medio-lateral overlap was greatest in Gorilla, reduced in Homo, and intermediate in Pan. By contrast, only Homo presents systematically a vertical overlap; a vertical overlap was sometimes observed in Pan, but never in Gorilla. Homo presented the greatest vertical overlap, and Gorilla the least; the disposition in Pan was intermediate. The interspecific study of the relationships between medio-lateral and vertical overlap in Gorilla, Pan, and Homo demonstrated that an increase in vertical overlap was correlated with a decrease of medio-lateral overlap. Sexual dimorphism in orbitonasal relationships was systematically greatest in Gorilla, and reduced in Pan and Homo, this is also the case for the orbital, nasal, and orbitonasal parameters measured in this study. All these results provide interesting elements for understanding the morphological evolution of the middle face in hominoids.

Key Words: Hominoids; Face; Orbital opening; Nasal opening; Image analysis.

INTRODUCTION

Quantitative studies of hominoid facial morphology in norma frontalis are rare, most of the studies being performed in norma lateralis (Aiello & Dean, 1990; Biegert, 1957; Bilsborough & Wood, 1988; Delattre & Fenart, 1960; Rak, 1983; Shea, 1985). The orbital and nasal openings are major structures of the face. These openings have been generally studied separately in order to characterize their size and shape (Martin & Saller, 1956; Glanville, 1969). The simultaneous study of the three facial openings is exceptional in the literature, but is necessary for the quantification of their relative positions. The determination of the positions of the centres of area of these openings (Schmittbuhl et al., 1996) constitutes an interesting approach for the study of their relative positions.

In order to establish the relative positions of the nasal and orbital openings precisely, we developed, from image analysis techniques, a new methodological approach based on the automatic determination of horizontal and vertical lines of reference. This allows the relative overlap between the nasal and orbital openings to be quantified in a frontal projection. In the present study, we applied this method in African great apes and human samples.
MATERIAL AND METHODS

OSTEOLOGICAL MATERIAL

The material consisted of 182 skulls subdivided as follows: *Gorilla gorilla*, 38 males and 20 females; *Pan troglodytes*, 19 males and 13 females; modern *Homo sapiens*, 51 males and 41 females. All of the skulls showed complete eruption of the permanent dentition and could therefore be considered as adult subjects. The skulls were also free from pathological changes. These specimens are in the collections of the Institut d’Anatomie Normale (Faculté de Médecine, Strasbourg), the Institut et Musée de Zoologie (Université Louis Pasteur, Strasbourg), and the Laboratoire d’Anatomie Comparée (Muséum National d’Histoire Naturelle, Paris).

IMAGE ANALYSIS SYSTEM

Image processing was performed with a HP VL2® 486 DX2-66MHZ microcomputer equipped with a frame grabber (Matrox Vision Processor®). Image capture was performed with a digital camera Kodak DCS 420® (image resolution of 1536×1024 pixels×8 bits) with a telephoto lens Nikon 2.8/200®. The camera was fixed on a macrophotography stand. A software package (Visilog®), providing all classical image processing tools, was used to visualize and analyze images.

PROCEDURE FOR IMAGE ANALYSIS

Positioning of the skull: Each skull was placed in a same reference position using the classical orbitomeatal plane. The skull was maintained with a cephalostat. The orbitomeatal plane was placed parallel to the horizontal plane of reference.

Image capture: The focal axis of the camera was parallel to the horizontal plane of reference, and centered between the orbital and nasal openings. The camera was set at 4.5 m from the nasion. The spatial image resolution was 1536×1024 pixels.

Segmentation of the orbital and nasal openings: A thresholding operation was used. Some small artifacts, such as facial sutures or foramina, were not eliminated; the image obtained was thus cleaned by a succession of classical morphological transforms (COSTER & CHERMANT, 1985).

DEFINITION OF FACIAL LINES

A procedure was developed to determine automatically horizontal and vertical lines of reference of the face (Table 1, Fig. 1).

Linear Measurements

For each skull, four heights were calculated automatically from the horizontal lines, and five breadths from the vertical lines (Table 2, Fig. 1).

Indices of Orbitonasal Overlap

For each skull, two indices were defined: