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An angio-tomographic approach to the study of the variation of the middle meningeal artery in humans

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Introduction. The middle meningeal artery usually enters the endocranial cavity through the foramen spinosum, running within the dura mater and developing a vascular network on the frontal, parietal, and occipital surfaces of the brain. Little information is available on its morphogenesis and variation in human populations or within primates (Falk 1993). Its imprints on the endocranial walls can be recognised on fossil specimens, allowing inferences on the evolution of this vascular system. While extinct human species display a limited reticulation of this vessels, Homo sapiens shows a definite increase of its complexity (Bruner et al., 2005). Current hypotheses on the evolution of a complex meningeal vascularisation in our species include biomechanical protection and thermoregulation of the brain surface (Bruner et al., 2011). Taking into account the limited knowledge on the variation of this arterial network, this study is aimed at quantifying individual differences in the branching patterns, as well as at investigating the spatial relationships between middle meningeal arteries, cerebral arteries, and neurocranial bones.

Methods. Angio-tomography and digital anatomy are used to reconstruct in vivo the meningeal vascular system in 37 individuals with age spanning from 20 to 85 years. Three-dimensional reconstructions of the cerebral and meningeal vascular systems have been computed by using Mimics 11.1 (Materialise Software). Variations in basic branching patterns have been described by standard anatomical approaches, as well as by using standard morphometrics. Complexity of the branching pattern has been quantified also by using fractal approaches (Zamir 1999).

Results. Anatomical descriptions and metrics are reported for different age classes, sexes, and hemispheres, providing mean values and ranges of distribution accounting for the vascular patterns.

Conclusions. Although the middle meningeal network shows a variable and complex geometry, its spatial organization can be quantified in terms of branching patterns and topological relationships with the neurocranial elements. This information allows to test evolutionary hypothesis by quantifying individual or between-groups differences. At the same time this information is helpful in biomedical and neurosurgical context, providing statistical values for the position and distribution of the vessels.

Keywords: Fractal geometry, angio-tomography, middle meningeal artery