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Variation of mandibular sexual dimorphism across human facial patterns

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ABSTRACT

This study analysed how sex-specific features differed in male and female adult mandibles throughout the spectrum of vertical facial patterns (i.e., meso-, dolicho- and brachyfacial) and sagittal variations (the so-called skeletal Classes I, II and III; normal maxillo-mandibular relationship, maxillary prognathism vs. mandibular retrognathism, and maxillary retrognathism vs. mandibular prognathism, respectively). Specifically, we test the hypothesis that sexual dimorphism in the mandible is independent of such facial vertical and sagittal patterns. A sample of 187 European adults (92 males, 95 females; age range, 20–30 years; mean age 25.6 years, sd = 4.2 years) from Granada (southern Spain) were randomly selected and grouped according to the standard cephalometric criteria of the sagittal and vertical patterns. Geometric morphometrics were used to analyse the size (centroid size) and shape (principal components analysis, mean shape comparisons) of the mandible. The patterns of sexual dimorphism were evaluated with a generalised linear model with interaction term. We found that sagittal and vertical facial patterns are associated with different mandibular morphologies (size and shape). Also, sexual dimorphism was present in all comparisons. The hypothesis was rejected only for vertical facial patterns. That is, the nature of sexual dimorphism was similar among the skeletal classes but different (e.g., distribution of dimorphic variables, interaction term) in meso-, dolicho-, and brachyfacial mandibles. In conclusion,

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sex-specific mandibular traits behave in a different way across vertical facial patterns. These results imply that an assessment of the vertical facial pattern of the individual is required before a sexual diagnosis of the mandible is proposed.

Introduction

A marked sexual dimorphism has frequently been reported in the human face and mandible, both in size and shape (Bulygina et al., 2006; Giles, 1964; Humphrey, 1998; Loth and Henneberg, 1996; Oettle et al., 2009; Rosas and Bastir, 2002; Ursi et al., 1993). The pattern of sexual dimorphism in the mandible (e.g., distribution of sexually dimorphic measurements) is, nevertheless, extremely variable, both between and within species. Within humans, the degree and pattern of sexual dimorphism are frequently recognised as highly population-specific (Bejdová et al., 2013; Frayer and Wolpoff, 1985; Hall, 1978; İşcan, 2005; MacLaughlin and Bruce, 1986; Ross et al., 2011; Wells, 2007), which has given rise to a number of studies directed to typify the population-specific pattern of sexual dimorphism of the skull and mandible (e.g., Franklin et al., 2008; Green and Curnoe, 2009; Kharoshah et al., 2010; Steyn and İşcan, 1998). Even more, Bulygina et al. (2006) detected changes in the pattern of facial shape differences between sexes along ontogeny, something already appreciated in mandibles along the adult life by Hunter and Garn (1972), who suggested the desirability of age specific discriminant function analysis. In this context, Coquerelle et al. (2011) found that males are characterised by a continuation of allometric shape changes from puberty to adulthood. In contrast, the shape of the female mandible continues to change even after the size has ceased to increase. As a consequence, adult dimorphism is concentrated at the ramus and mental region, during the earliest ontogenetic stages and again at adulthood. At age 20 in males, the coronoid process is positioned more backward and upward; the gonion is pointed more downward; and the basal symphysis is oriented more downward than in females. Rosas and Bastir (2002) found a dimorphic superoinferior positioning of the mental region, upward in females versus downward in males. In their study, they extracted three features potentially useful for sexual diagnosis in the mandible: the curvature of the anterior symphysis, the development of the preangular notch, and the flexion of the ramus. Thayer and Dobson (2010) examined patterns of quantitative variation in modern human chin shape in order to evaluate different hypotheses about the functional significance of the chin. They found significant differences in chin shape between sexes, and the male mandibular symphyses tending to be taller and the *mentum osseum* more protrusive than females. These authors concluded that any hypotheses for the function of the human chin must take into account sexual dimorphism in chin shape.

On the other hand, some specific features are identified as sexually dimorphic in one population whereas the very same features are not necessarily valid for the sexual diagnosis in another population (Bejdová et al., 2013; Garvin and Ruff, 2012). Simultaneously, there are also some variables in the mandible that are more sexually diagnostic across populations, like height of the ramus (Humphrey et al., 1999; Hunter and Garn, 1972).

Sexual dimorphism of the adult mandible has also been confirmed, although to a lesser extent, in malocclusive groups (Baccetti et al., 2005; Battagel, 1993; Wellens et al., 2013). Nevertheless, Riesmeijer et al. (2004) and Generoso et al. (2010) did not find differences in mandibular lengths between adolescent males and females with skeletal Class II malocclusion (i.e., maxillary prognathism vs. mandibular retrognathism).

In this context, knowing the factors that determine the variation in the pattern of sexual dimorphism of the mandible is relevant in biological anthropology, the implications of which disseminate also into paleoanthropology, paleodemography, forensics or orthodontics.

Explanations for the sexual dimorphism pattern in the mandible and its large variation are diverse, but the biological determinants by which differences between males and females are reached remain elusive. Bejdová et al. (2013) proposed that sexual dimorphism of mandible size could be influenced