Archives of Oral Biology 84 (2017) 64–73

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/archoralbio

Research Paper

Facial skeleton asymmetry and its relationship to mastication in the Early Medieval period (Great Moravian Empire, Mikulčice, 9th–10th century)

Alexandra Ibrová[a,*], Ján Dupej[a,b], Petra Stránská[c], Petr Velemínský[d], Lumír Poláček[e], Jana Velemínská[a]

[a] Department of Anthropology and Human Genetics, Faculty of Science, Charles University, 128 43, Prague, Czech Republic
[b] Department of Software and Computer Science Education, Faculty of Mathematics and Physics, Charles University, 118 00, Prague, Czech Republic
[c] Institute of Archaeology of the Academy of Sciences of the Czech Republic, 118 01, Prague, Czech Republic
[d] Department of Anthropology, National Museum, 115 79, Prague, Czech Republic
[e] Institute of Archaeology of the Academy of Sciences of the Czech Republic, 602 00, Brno, Czech Republic

ARTICLE INFO

Keywords:
Mandible
Teeth
Dental wear
Diet
Geometric morphometrics

ABSTRACT

Objectives: The aim of this study was to analyse the relationship of mastication and directional asymmetry (DA) of upper facial skeleton in Early Medieval sample from the Mikulčice settlement (Czech Republic).
Design: The settlement is divided into two burial areas of presumably different socioeconomic status: the castle and the sub-castle. The material consisted of 193 individuals (125 castle, 68 sub-castle). The relationship of facial skeleton DA and mastication was analysed by examining tooth wear and mandibular shape by means of 3D geometric morphometrics. Tooth wear of premolars and molars was evaluated using appropriate scoring systems. 3D coordinates of 35 mandibular landmarks were scanned using MicroScribe G2X digitizing system.
Results: The results did not reveal any significant differences in tooth wear DA or mandible DA values between burial areas or sexes. Mandibular shape, however, differed significantly between burial areas and sexes. Directional changes of mandibular landmarks supported a right chewing side preference in the sample. Significant relationship between upper facial skeleton DA and mandible DA was recorded.
Conclusions: Differences in subsistence between burial areas and sexes did not translate into differences in mandible DA and dental wear. However, mandibular shape analysis revealed prominence of areas affected by masticatory muscles in individuals from the castle. Higher consumption of tough material, such as meat, has been proposed as possible explanation. The right side was found to be preferential for chewing. The relationship between upper facial skeleton DA and mandible DA was concluded to be the result of the compensatory and adaptive function of mandible.

1. Introduction

The structures of the human body are of a fairly asymmetric nature. Asymmetries may develop as a result of environmental, genetic or biomechanical factors. Anthropological research focuses mainly on two types of asymmetry – fluctuating asymmetry (FA) and directional asymmetry (DA). Fluctuating asymmetry is connected mainly with the ability of the organism to cope with environmental stress whereas directional asymmetry is connected with biomechanical load (for a review see Graham, Raz, Hel-Or, & Nevo, 2010). There are many studies indicating DA to be a component of greater importance than FA for the interpretation of cranial and facial asymmetries (Ercan et al., 2008; Quinto-Sánchez et al., 2015; Schaefer, Lauc, Mitteroecker, Gunz, & Bookstein, 2006).

The facial skeleton is a structure with bilateral symmetry, as it consists of two mirror images that are roughly symmetric about a plane (Mardia, Bookstein, & Moreton, 2000). If deviations from perfect symmetry are consistent within a population, directional asymmetry is present (Palmer, 1994; Van Valen, 1962). Directional asymmetry might be also of an adaptive nature in cases of structures with a matching type of symmetry that are present as two separate corresponding objects (e.g. human limbs) (Palmer, 1994), each of which is exposed to a different biomechanical load. A typical example is functional laterality of limbs caused by preferential use of one side of the body (Auerbach & Ruff, 2006; Kujanová, Bigoni, Velemínská, & Velemínský, 2008; Özener, 2010; Sládek, Ruff et al., 2016; Sládek, Hora,

Abbreviatons: DA, directional asymmetry; FA, fluctuating asymmetry; IA, individual asymmetry

* Corresponding author at: Department of Anthropology and Human Genetics, Faculty of Science, Charles University, Viničná 7, 128 43 Prague 2, Czech Republic.
E-mail address: ibrovaa@natur.cuni.cz (A. Ibrová).

http://dx.doi.org/10.1016/j.archoralbio.2017.09.015
Received 20 March 2017; Received in revised form 14 September 2017; Accepted 17 September 2017

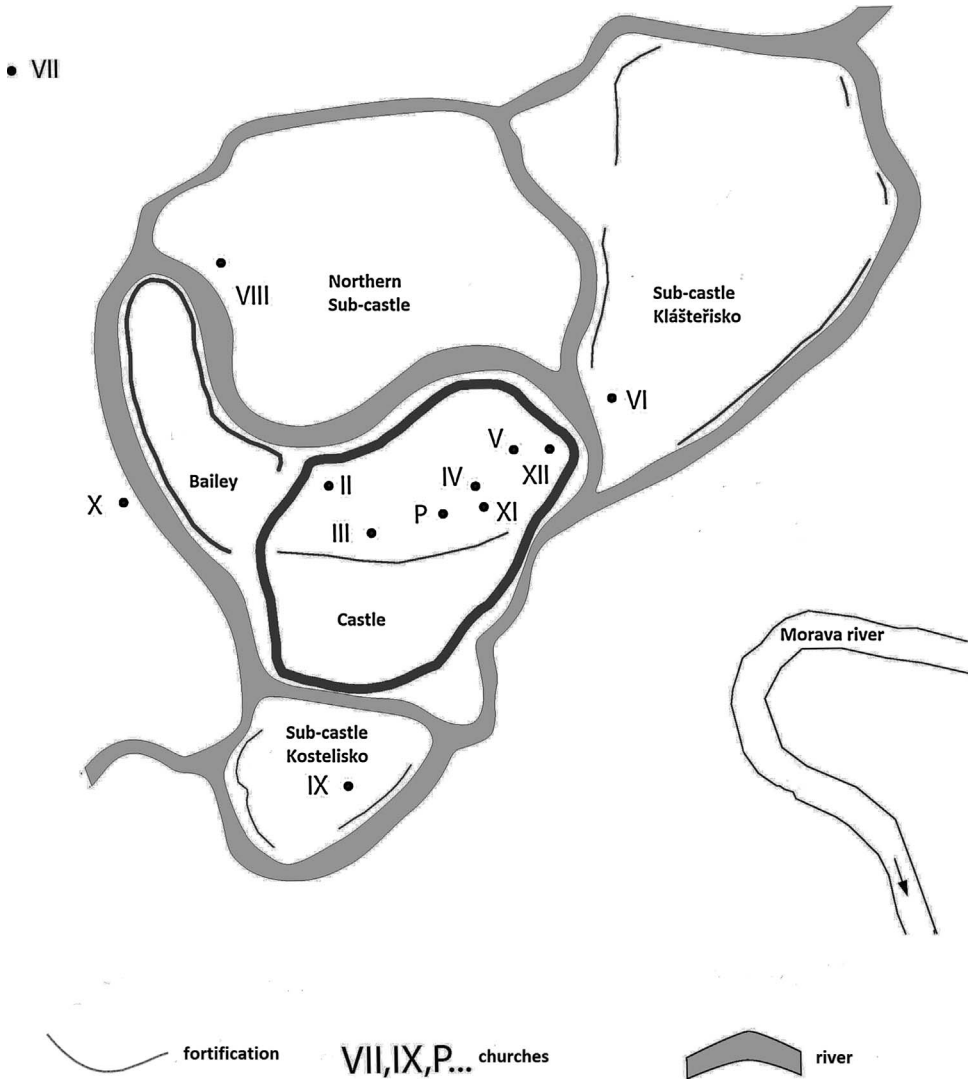

Fig. 1. Map of the Mikulčice settlement (modified after Bigoni et al., 2013; Poláček, 2008).

Farkašová, & Rocek, 2016).

In the literature there is no unanimous view regarding the actual origin of directional asymmetry. The study of Moreira, Sgrott, Stuker, Alonso, & Smith (2008) found palatal asymmetry in the fetal period, when the shape of the palate cannot be affected by the activity of the masticatory apparatus. Also, increased DA is connected with certain developmental disorders (Hammond et al., 2008; Klingenberg et al., 2010) and increases in populations with higher levels of inbreeding (Schaefer et al., 2006). On the other hand, very low heritability of dental arch shape was found when it was studied in siblings (Cassidy, Harris, Tolley, & Keim, 1998). One possible explanation might be that both genetic and environmental forces contribute to the formation of directional asymmetry (Schaefer et al., 2006); strong genetic regulation (Gurnett et al., 2008) is present at the beginning of development, and the influence of biomechanical factors increases with age (Šlaj, Ježina, Lauc, Rajić-Meštrović, & Mikšić, 2003).

Nevertheless, one of the main environmental and functional sources of directional asymmetry in the facial skeleton is mechanical load produced by chewing muscles during mastication. A change of diet might affect not only the shape of the facial skeleton, but also the shape of the cranial vault (Carlson & Van Gerven, 1977; Menegaz et al., 2010). The masticatory system is a complex unit consisting of the lower and upper jaw, teeth and temporomandibular joints. During mastication, the cusps of antagonistic teeth of mandibular and maxillary dental arches come into physical contact, resulting in tooth attrition (Kaidonis, 2008), which is a type of tooth wear. Without the presence of exogenous particles, it is a physiological process. Besides tooth attrition, tooth wear is also caused by abrasion, which involves contact of the dental surface with exogenous material, and by erosion when the tooth surface is dissolved by chemical substances of high acidity (for a review see Esclassan et al., 2015). Tooth wear of past populations is usually a result of interactions between attrition and abrasion (Kaidonis, 2008), which is also the case of our sample. The level and type of tooth wear carry information about the diet, eating habits and chewing side preference, but also about health, demographic structure and lifestyle in general (e.g. Lieverse, Link, Bazaliiskiy, Goriunova, & Weber, 2007; Novak, 2015; Smith, 1984; Tomczyk & Zalewska, 2016). However, even populations living in the same eco-geographic conditions may differ in tooth wear because of varying food preparation techniques, which also play an important role (El Zaatari, Grine, Ungar, & Hublin, 2011; Smith, 1972; Watson, Arriaza, Standen, & Muñoz Ovalle, 2013).

In general, mastication is mostly unilateral with the side of preference more frequently on the right side of the dental arch (Diernberger, Bernhardt, Schwahn, & Kordass, 2008), which causes a higher degree of tooth wear on the preferential side. Also, tooth wear is more advanced in populations eating diets with higher levels of hardness or abrasiveness, which allows us to observe differences between populations with different subsistence strategies (Deter, 2009). Since mastication is a very complex process, unilateral mastication does not only affect the dentition, but also the facial skeleton, and especially the