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Tooth fractures in the Krapina Neandertals

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A B S T R A C T

Dental fractures can be produced during life or post-mortem. Ante-mortem chipping may be indicative of different uses of the dentition in masticatory and non-masticatory activities related to variable diets and behaviors. The Krapina collection (Croatia, 130,000 years BP), thanks to the large number of teeth (293 teeth and tooth fragments) within it, offers an excellent sample to investigate dental fractures systematically. Recorded were the distribution, position and severity of the ante-mortem fractures according to standardized methods. High frequencies of teeth with chipping in both Krapina adults and subadults suggest that the permanent and deciduous dentition were heavily subjected to mechanical stress. This is particularly evident when the frequencies of chipping are compared with those in modern humans (Upper Paleolithic and historic samples) that we analysed using the same methods. The distribution of chipping in the Krapina sample (anterior teeth are more affected) and its position (labial) suggest a systematic use of the anterior teeth for non-masticatory tasks.

1. Introduction

Dental crown chipping is a quite common event, well-known in dentistry and oral epidemiological reports (cf. Bader et al., 2001), and frequently is the result of mechanical trauma related to the clenching of foreign objects between occluding or adjacent teeth during masticatory or non-masticatory activities. These include para-masticatory activities such as food processing and extra-masticatory functions when holding objects during tool manufacture and retouching. Unusually pronounced compressive force between opponents can also cause chipping (Scott and Winn, 2011). The contact with foreign bodies, in which the hard inelastic impact briefly transmits energy to a small area of the crown, often leads to crown fractures. In contrast, falls or injuries during a fight are more likely to result in luxation, alveolar fractures or exarticulation, as observed in clinical studies of traumatic dental injuries by Andreasen (1970) and Lešić et al. (2011). The severity of the fractures (from minor enamel flakes to major damage), the distribution among different teeth and their position on the crown provide information about the use of the dentition in past populations. For example, molar- and incisor-dominant patterns have been observed in prehistoric hunters and agriculturalists, respectively (with some exceptions) related to preparation techniques (e.g., stone, wood and metal grinding implements) (Scott and Winn, 2011) and to use of teeth as tools (Merbs, 1968) especially in males (Wood, 1992). The positions of chipping on the crown can relate to substantial use of the teeth as a third hand (high frequencies of labial chipping) or the presence of contaminants in the diet (interproximal chipping) (Bonfiglioli et al., 2004; Belcastro et al., 2007). In fossil hominins the study of dental chipping and other dental alterations related to para- and extra-masticatory activities is very useful because, being scarce elements of material culture, they provide a picture of the ability of these populations to adapt to the territory and environment, as already observed by Lozano et al. (2008).

Among the many studies that have examined dental features of the Neandertals to infer alimentary and non-alimentary behaviors of these hominins (Kallay, 1951; Wallace, 1975; Smith, 1976a, 1976c; Trinkaus, 1978; Puech, 1981; Frayer and Russell, 1987; Bermúdez de Castro et al., 1988; Lalueza-Fox and Pérez-Pérez, 1993; Villa and Giacobini, 1995; Lalueza-Fox et al., 1996; Lalueza-Fox and Frayer,

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1997; Pérez-Pérez et al., 2003; Lozano et al., 2008, 2013; El Zaatari et al., 2011; Topić and Vučičević-Boras, 2003; Clement et al., 2012; Hardy et al., 2012; Krueger and Ungar, 2012; Topic et al., 2012; Hlusko et al., 2013; Guatelli-Steinberg et al., 2014; Fiore et al., 2015; Karriger et al., 2016; Frayer et al., 2017; Weyrich et al., 2017), none has specifically dealt with chipping. Other studies more focused on the description of dental characters have mentioned the presence of chipping (de Lumley, 1973; Lalueza-Fox and Frayer, 1997; Bailey and Hublin, 2006; Estalrrich and Rosas, 2015), but there have been few systematic investigations of this feature in Neandertals. A recent paper dealing with the fractures in the permanent teeth of *Homo naledi* shows 44% of teeth affected, with more chipping on the posterior teeth (Towle et al., 2017). Other studies report on tooth fractures in modern humans (Turner and Cadien, 1969; Milner, 1984; Milner and Larsen, 1991; Bonfiglioli, 2002; Bonfiglioli et al., 2004; Belcastro et al., 2007; Scott and Winn, 2011), but none has compared differences between archaic and modern humans.

The Krapina hominid collection represents the largest sample of Neandertal dental specimens ever found at the same locality (Wolpoff, 1979; Smith, 1982; Trinkaus, 1985; Caspari and Radovčić, 2006; Frayer, 2006; Monge et al., 2008). The dental collection is well-preserved and represents a significant portion of the total number of Neandertal teeth currently available for study. Some specific alterations, artificial grooves in the interproximal spaces of the posterior teeth (Frayer and Russell, 1987), dental scratches, mostly right-hand made on the labial surface of anterior teeth (Lalueza-Fox and Frayer, 1997; Fiore et al., 2015), microwear texture on anterior teeth related to moderate abrasive loads (Krueger and Ungar, 2012) and on posterior teeth connected to high meat consumption (Karriger et al., 2016), have been published. Recently the four teeth making up Krapina Dental Person (KDP) 20 have been used to argue for manipulative procedures on a rotated P_4 and a partially impacted M_3 (Frayer et al., 2017). As regards the dental fractures, besides the first study of Kallay (1951), until now no systematic studies have been provided on the Krapina teeth.

The aim of this study is to systematically count and analyse in detail the dental fractures in the Krapina Neandertals utilizing our standardized methodologies (Bonfiglioli, 2002; Belcastro et al., 2004; Bonfiglioli et al., 2004) to infer the rate of the mechanical stress on the teeth and possible etiological factors distinguishing among masticatory and non-masticatory agencies. Taking into account that high mechanical stress has already been hypothesized for Krapina teeth in previous research, we would predict a high rate and severe degree of chipping. Finally, we also compared the Krapina teeth with other Pleistocene and Holocene human tooth samples recorded by the authors with the same methodology, hypothesizing a different pattern of Krapina dental fractures compared to the modern samples.

2. Krapina Neandertal site

Excavations in the Hušnjakovo rock shelter in the town of Krapina (Croatia), conducted by Dragutin Gorjanović-Kramberger between 1899 and 1905, brought to light hominid remains associated with Middle Paleolithic tools and fauna. The layers where human remains were found indicate a different or more intensive use of the site at those times, especially the *Homo* zone, where there is a very high frequency of hominids and lithics compared to other layers. It is now thought that the entire sequence covers a short time period, since electron spin resonance (ESR) and uranium-(U) series dates derived from the top and bottom are roughly the same, about 130,000 years BP (Rink et al., 1995). Gorjanović-Kramberger originally interpreted the sequence as spanning no more than about 8000 years (Caspari and Radovčić, 2006). The fauna is consistent with an interglacial environment, although the presence of marmots at the top of the sequence may indicate somewhat cooler, more arid conditions (Miracle, 2007). In some layers (5–7), the environment may have become a bit more open, with more grassland, as indicated by an increase in the frequency of *Bos*/*Bison*. This could suggest fluctuations within the interglacial or reflect faunal movement or different hunting strategies without significant environmental change. Krapina is situated at the edge of more hilly, higher terrain (Miracle, 2007) and the environment inhabited by the *Homo* zone Neandertals consisted of lush parkland close to the Krapinica stream, affording them a rich diet of plants and animals (Caspari and Radovčić, 2006). Based on the dates and faunal composition of the site, most if not all of the Krapina hominids likely derive from the beginning of the last interglacial, at oxygen isotope stage 5e or the 6/5e transition and lived in a temperate climate, with mean temperatures perhaps 1 °C or 2 °C warmer than in the 20th century (Caspari and Radovčić, 2006).

The collection of animal and human bones at Krapina is extensive with over 2000 faunal elements and a minimum number individuals of more than 100 animals (Miracle, 2007). For the human remains, there are over 900 cranial and postcranial elements including 199 isolated teeth. Estimates for the minimum number of Neandertals at the site have varied widely. Gorjanović-Kramberger (1913) estimated at least 10 individuals, but Salopek (1969) revised this to 20 individuals. More modern estimates have varied from a low of 23 individuals based solely on unpublished inventories of mandibles and maxillae by White and Toth (as reported in Bocquet-Appel and Arsuaga, 1999) to a high of 82 individuals, determined from tooth sets catalogued by Wolpoff (1979).

3. Materials

The Krapina dental collection consists of mandibles, maxillae and isolated teeth from subadults and individuals no older than 30 years (Wolpoff, 1978, 1979; Radovčić et al., 1988; Wolpoff and Caspari, 2006). No sex attribution has been published for the isolated dental sample and, according to Wolpoff (1979, p. 104), “no dental evidence can be used to sex specimens or provide estimates of the degree of dimorphism” even though sexual dimorphism has been reported, especially for the anterior teeth (Lee, 2006). Complete inventories of the teeth and human bones are available (Kallay, 1963; Trinkaus, 1975; Smith, 1976b; Musgrave, 1977; Wolpoff, 1979; Radovčić et al., 1988; Kricun et al., 1999), but there is still disagreement about the estimated minimum number of individuals (cf. Ullrich, 2006).

In this study, we refer to numbered Krapina teeth in jaws and isolated teeth assembled into Krapina Dental Persons (KDP) published in the volume by Radovčić (1988) where the condition (completeness, fracture, damage, etc.) of the teeth has been indicated. Some still unpublished, new attributions of the teeth have been made by people (e.g., Wolpoff, Frayer, Coppa, Belcastro and Bonfiglioli) who have visited the dental collection over the years, and we have incorporated these into our analyses. Definitive associations between maxillae, mandibles and teeth are still debated. The Krapina dental remains are represented by 293 teeth and tooth fragments (199 are isolated teeth and 94 are in jaws). For the age at death, we refer to the estimations by Wolpoff (1979) and Radovčić et al. (1988): among adult maxillae and mandibles, there are five specimens of 14–16 years, one of 17–19 years, and five older than 20 years. The subadult group includes maxillae and mandibles of individuals aged 5–11 years. Isolated teeth include both subadults and adults.

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