Tooth wear pattern analysis in a sample of Italian Early Bronze Age population. Proposal of a 3-D sampling sequence

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A B S T R A C T

Objective: The purpose of this study was to assess the prevalence, distribution and intensity of tooth wear in a sample of an ancient Italian population in order to explain the pattern in terms of dietary habits and/or non-dietary tooth-use behaviors during the Early Bronze Age, with a focus on possible age-group and sex differences.
Design: Well-preserved permanent teeth of individuals from the Bronze Age site of Ballabio (Lecco) in northern Italy were examined for tooth wear by different methods. Eight 3D models of teeth at increasing severity of wear were created.
Results: In total, 357 permanent teeth belonging to male and female individuals were included in the study. Dental wear was present in 96.6% of the total sample. Males showed significantly greater levels of wear than females in the mandibular teeth. Both sexes exhibited a significantly different wear direction between the anterior (oblique and flat) and posterior (oblique and concave) teeth. Significant age differences were observed in the direction and level of wear in the incisors, canines and premolars, with higher wear in the older group. Complete and rotatable virtual 3D images of different wear patterns are proposed.
Conclusions: The findings of the present study confirm the data from archaeological studies on this site and on northern Italian habits during the Early Bronze Age suggesting a diet rich in vegetables. The observed wear patterns can be related both to the diet of this Bronze age population, based on hard and abrasive food requiring vigorous mastication, and to sex differences in cultural practices.

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1. Introduction

Teeth represent enduring physical evidence of the existence of an individual after death, constituting an optimal material for scientific research on many aspects of past human behaviors and ways of life. Dental health, considered closely related to subsistence patterns (Eshed, Gopher, & Hershkovitz, 2006; Molnar, 2011), is often used to evaluate the diet and differences in food-preparation techniques of past populations. The study of dental wear in ancient populations can provide important indications of possible dietary effects or non-dietary uses of the teeth, e.g. as a tool for working activities (Estalrrich & Rosas, 2015; Molnar, 2011).

Particular emphasis has been given to the different patterns of dental wear after the introduction of agriculture (Eshed et al., 2006; Spencer Larsen, 1995).

Tooth wear occurred intensively in past populations, mainly in relation to cultural factors such as diet and food preparation techniques. Wear depends on the physical and chemical composition of foodstuffs (soft or abrasive) and on amounts of grit from millstones used to grind the food (Esclassan et al., 2009; Masotti, Onisto, Marzi, & Gualdi-Russo, 2013). Hunter-gatherers and early agricultural groups show evidence of abnormal abrasion, apparently due to the use of the teeth for preparing food or in the manufacture of artifacts: heavy scratching on the labial surface of the incisors probably represents the cutting of objects held between the teeth. In addition to the unintentional dental wear reported above, some forms of intentional dental wear can be due

to the wearing of labrets or tooth mutilation by cutting, drilling or filing (Hillson, 2007).

The effectiveness of dental microwear in revealing the diet has been debated recently (Xia et al., 2015).

Microscopic wear on teeth is caused by hard abrasive particles and by tooth-on-tooth contact during chewing (Walker, Hoeck, & Perez, 1978). Microwear consists of pits (microwear features with a length to-width ratio less than four-to-one) and scratches (linear microwear features with a length to-width ratio greater than four-to-one) (Maas, 1994; Schmidt, 2010): pits result from compression of food or contaminant particles on the enamel surface of teeth during the power stroke (Maas, 1994); scratches originate from to the manner in which particles are dragged between opposite enamel surfaces of the teeth (Ryan, 1979). Therefore, changes in dietary habits can be evaluated through the frequency, size, orientation and morphology of pits and scratches (Mahoney, 2007).

Italy exhibits various geographical and environmental conditions under which human populations could have lived during the Bronze Age. It has a great variability of climate, flora and fauna due to the different geographical conditions, such as the high mountains in the north (Alps), the wide coastal plains facing the Tyrrhenian and Adriatic seas and a long mountain range running along the entire peninsula, plus the large islands (Sicily and Sardinia) in the Mediterranean Sea. The social structure of human groups living in northern Italy during the Bronze Age was tribal (Bietti Sestieri, 2011) or patriarchal (Peroni, 1971), with small communities (about fifty persons in the Early Bronze Age, according to Peroni (1971) gravitating around the lakes. Small villages built on stilts were located short distances from each other on the banks of water bodies (Bietti Sestieri, 2011). There were trade networks both between various Italian communities (even those located in remote areas) and between northern Italy and transalpine Europe (finding of amber) (Bellintani, Angelini, Artioli, & Polla, 2006). Wooden tools, such as plows and sickles, and burned cereal seeds (beans, barley, corn, millet) testify to agriculture activities. Breeding concerned mainly sheep and goats (especially in mountain areas), pigs and cattle. Hunting always played a major role.

Very few studies on the dental health of Italian Bronze Age populations have been published in international journals (Cucina, 2002; Dori & Moggi-Cecchi, 2014) and none of them examined tooth wear. Since tooth wear patterns may provide further knowledge of eating habits and lifestyles, we analyzed this feature in past inhabitants of Ballabio, a site discovered in the Alps in the Balisio Valley (Valsassina, Lombardy) at about 700 m above sea level.

Despite the small sizes of Italian Bronze Age communities in the pre-Alpine area (Bietti Sestieri, 2011; Cucina, 2002), the anthropological study of these samples is a unique opportunity to acquire new insights into the diet and extra-masticatory behaviors about 5000 years ago. With this main purpose, we investigated the dental wear patterns in a skeletal sample from Ballabio (Lombardy region, Italy), focusing on several biological aspects by different methods. This study analyzed possible differences between the sexes and between younger and older age-groups in the wear frequency and pattern, aspects poorly documented in Early Bronze Age populations from Italy. Moreover, in view of the possibility of useful applications of virtual records to many research areas, and in particular to orthodontic and orthognathic studies (Fiorenza, Benazzi, & Kullmer, 2009; Hajeer, Ayoub, & Millett, 2002; Rangel et al., 2008; Solaberrieta et al., 2016; Verweij et al., 2015), we propose new 3D dental wear models that could be used by both archaeologists and clinicians to identify different levels of wear in the anterior teeth and premolars.

2. Materials and methods

2.1. Sample and wear evaluation

This study was carried out on the human skeletal remains excavated in a rock shelter at 700 m above sea level at Ballabio (Lecco, Italy). This archaeological site was discovered in 2004 during a geological survey, when skeletal remains were found in two adjacent funerary structures interpreted as primary burials and as places of secondary deposition (Lorenzi, Corti, & Gaetani, 2009; Manzon, Thun Hohenstein, & Gualdi-Russo, 2012). The results of different methodologies (archaeological artifacts, radiocarbon dating, geological stratigraphy) indicate that the examined individuals lived in this site during the Early Bronze Age (3230 ± 90 BP) (Lorenzi et al., 2009).

The sex and age at death of the examined individuals were determined previously (Gualdi-Russo, Onisto, & Vascon, 2009; Manzon et al., 2012) by standard anthropological methods (Acsádi & Nemeskéri, 1970; Ferembach, Schwidetzky, & Stloukal, 1980). At least 27 inhumations were documented (22 adults and 5 sub-adults). This MNI was determined on the basis of the maximum number of the same tooth type (lower left second premolar on one side of the mandible).

Only well-preserved permanent teeth were included in the study. Each tooth was identified according to its type, side and arch. The total number of permanent teeth inspected was 357, from at least 22 adult individuals (6 females, 3 males, 13 undetermined). All permanent teeth were examined macroscopically and with a magnifying glass to find evidence of dental wear. According to the age at death, the individuals were assigned to one of two age-groups used to analyze differences in dental wear: <35 and ≥35 years.

Dental wear was recorded for each tooth in terms of occurrence and location (anterior or posterior; maxillary or mandibular; right or left). The level of wear was determined by different methods: Smith's eight-grade scale system for anterior teeth and premolars (Smith, 1984), Scott's method for molars (Scott, 1979). Wear was also classified into different morphotypes by the method of Grimoud et al. (2012).

According to Smith's system (Smith, 1984), the wear was classified from mild (1) to heavy (8). The descriptions of various stages of occlusal surface wear are: 1) unworn to polished or small facets (no dentin exposure); 2) point or hairline of dentin exposure in anterior teeth and moderate cusp removal (blunting) in premolars; 3) dentin line of distinct thickness in anterior teeth and full cusp removal and/or moderate dentin patches in premolars; 4) moderate dentin exposure, no longer resembling a line in anterior teeth and at least one large dentin exposure on one cusp in premolars; 5) large dentin area with enamel rim complete in anterior teeth and two large dentin areas (may be slight coalescence) in premolars; 6) large dentin area with enamel rim lost on one side or very thin enamel only in anterior teeth and dentinal areas coalesced, enamel rim still complete in premolars; 7) enamel rim lost on two sides or small remnants of enamel remain in anterior teeth and full dentin exposure, loss of rim on at least one side in premolars; 8) complete loss of crown, no enamel remaining; crown surface takes on shape of roots in anterior teeth and severe loss of crown height, crown surface takes on shape of roots in premolars.

The occlusal surface of molar teeth was divided according to Scott (Scott, 1979) into four quadrants and the amount of observable enamel was scored on a scale of 1 to 10. The final score recorded for each tooth was the sum of the scores of all quadrants, yielding a minimum score of 4 and a maximum score of 40.