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NON-OCCLUSAL DENTAL MICROWEAR IN A BRONZE-AGE HUMAN SAMPLE FROM EAST SPAIN

ABSTRACT: Dental microwear analyses have shown to reflect important information of diet and feeding behaviour in ancient human groups. Quantitative works on molar tooth microwear in bioarchaeological populations have provided excellent data that explain the differences in subsistence economies among different ecological niches. In this study we examine preliminary buccal tooth microwear results in Bronze Age human groups from Spain. The microwear density and length by orientation recorded on micrographs using a scanning electron microscope (SEM) showed inter-group differences related to the amount of abrasives in the diet that could correspond to a different dependence on agricultural resources or food preparation technology.

KEYWORDS: Dental microwear – Teeth – Bronze Age – Diet

INTRODUCTION

Microscopic wear patterns analysed on small electronic map areas obtained by Scanning Electron Microscopy (SEM) on occlusal or non-occlusal molar surfaces have shown the usefulness of examining tooth use and physical properties of the foods eaten by paleontological and archaeological samples (see Rose, Ungar 1998, Teaford 1994, Villa, Giacobini 1998, for reviews).

There is a clear association between exogenous grit or intrinsic abrasive particles such as silicious opal phytoliths on the food eaten and dental microwear formation (Danielson, Reinhard 1998, Gügel *et al.* 2001, Lucas, Teaford 1995) but not between the type of abrasive and microwear morphology. The result of this phenomenon proves that abrasives in the food along with the masticatory action leave a clear enamel imprint. Although abrasive particles in food such as phytoliths or exogenous grit are the principal factor on the process of dental microwear formation, feature fabrics number, length and width present differences on surfaces. Microwear on enamel surface facets are basically categorized as pits (features with a length/width ratio of less than 4:1) and scratches or striations (length/width > 4:1). Experimental occlusal microwear research has shown that the teeth of humans who ate soft foods have fewer microwear features than those with abrasive diets (Teaford, Tylenda 1991, Teaford, Lytle 1996). Therefore, differences related to food texture must show specific microwear patterns in human teeth.

Non-occlusal surfaces have less tooth-to-tooth contact than occlusal surfaces, and their microwear is not influenced by contact between opposing teeth. If microscopic features are related to abrasive particles on foodstuffs, the relative differences in inter-group microwear patterns can reflect specific diets. Research has documented an important shift in dental microwear patterns from hunter-gatherer to subsistence agriculture, showing that embracing an agricultural lifestyle resulted in a significant alteration in the human diet, brought about a reduction in food toughness and changed the role of the teeth in food breakdown in a scenario of cultural transformations of food preparation technology.

Quantitative microwear research has been carried out on the occlusal molar surface in prehistoric human groups,

TABLE 1. Sample sizes of permanent teeth studied from Bronze Age groups. Group: Bronze Age groups; N: number of individuals; SA: subadults between 14 and 17 years of age; A: adults more than 18 years old; I: total number of SEM micrographs taken.

Group	N	SA	A	M1	M2	I
1	8	3	5	6	2	30
2	6		6	3	3	22
3	6	3	3		6	27
All	20	6	14	9	11	79

though little attention has been paid to assessing the implications of microwear pattern on non-occlusal surfaces. Molar occlusal microwear analysis has found age-related differences between horticulturalist and agriculturalist groups (Bullington 1991), changes in pitting incidence between hunting and gathering for marine resources and dependence on maize agriculture (Teaford 1991), differences in plant constituents between forager groups (Schmidt 2001) and microwear patterns related to changes in diet and food preparation technology (Molleson *et al.* 1993) as well as from prehistoric populations belonging to different cultures (Gambarotta 1995). Non-occlusal microwear research, on the other hand, has examined a variety of human groups, finding age-related variability in the number and length of features in agriculturalist groups (Pérez-Pérez *et al.* 1994) and a high density of striations related to the presence of abrasives (Lalueza *et al.* 1996). In research on ancient humans, the microwear examination of tooth surface proves to be useful, as diet differences and food preparation techniques may show a relative correlation with enamel loss. The purpose of this study was to examine inter-group differences in the microwear patterns of buccal molar surfaces among several bioarchaeological Bronze Age groups.

MATERIAL AND METHODS

Permanent left lower molars of Bronze Age human groups from several archaeological sites were examined (*Table 1*). Sex was mostly determined using the postcranial skeleton and age was estimated using cranial sutures and dental development and eruption (Buikstra, Ubelaker 1994). The selected tooth sample was classified into subadult (SA) and adult (A) age groups; sex was not taken into account in this analysis. All specimens were obtained from different museums and collections from Alicante, Valencia and Castellón. Teeth from the same period and other prehistoric (Neolithic and Chalcolithic) and historic (Roman and Medieval) epochs are being processed at present.

The Bronze Age sample was taken from the archaeological fieldwork in Aspe (Alicante, Spain) at the end of the 1980s. Eight human skeletal remains (Group One) were examined from the total sample. Most individuals lived between Early Bronze Age (2,000/1,900 to 1,800 BC) and Lower Bronze Age (1,300 to 1,100/1,000 BC). Six individuals (Group 2) from Almansa (Albacete, Spain), dating between 1,640 to 1,460 BC, were also studied. Finally, Bronze Age burials found in the Cova dels Blaus site in Vall d'Uixó (Castellón, Spain) (Group 3) were recovered during the 1995 campaign, in which at least 9 inhumations were documented (6 adults and 3 children) (Polo *et al.* 2002). A sample of mandibulary molar teeth of adult humans were used in this study.

The isolated teeth were cleaned with acetone and ethanol, washed with distilled water and subsequently air-dried. Non-occlusal molar enamel surfaces were directly examined, almost perpendicularly oriented to the electron beam, in a variable pressure SEM mode with a Hitachi S-3000N (*Figure 1*) using 20 kV in back-scattered electron emission mode (Romero, De Juan 2003, Romero *et al.* 2003). Micrographs were taken at 100x magnification

TABLE 2. Summary statistics of the number and length for the analysed groups. G: Bronze Age group; N: number of analysed individuals.

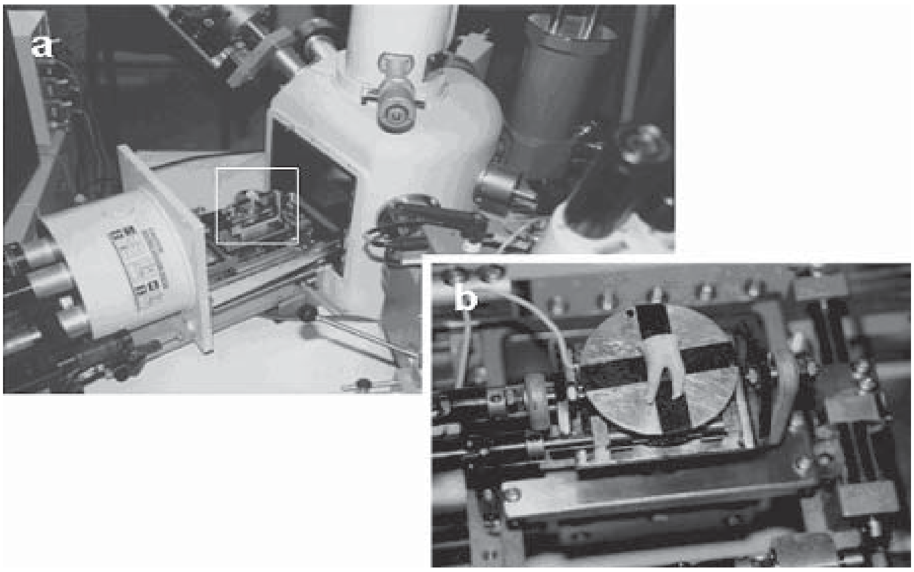
Number of striations

Group	n	MD		V		H		DM		All	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	8	24.75	15.76	53.75	21.57	22.75	7.75	33.75	25.01	135.00	44.44
2	6	32.50	16.57	85.50	27.32	30.83	4.07	39.33	20.02	188.16	25.25
3	6	29.16	9.53	45.66	10.36	13.66	7.36	26.16	12.44	114.66	10.83

Length of striations

Group	n	MD		V		H		DM		All	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	8	119.74	66.90	138.84	96.07	111.04	87.08	123.55	93.94	126.83	89.83
2	6	140.96	95.52	165.32	98.31	107.12	44.39	124.70	63.89	143.08	87.38
3	6	79.48	11.26	112.35	30.48	76.43	3.10	90.77	28.86	96.60	55.69

FIGURE 1. a: vacuum chamber of the SEM Hitachi S-3000N used in this study for exploring enamel molar teeth. b: position of the isolated teeth for the buccal surface analysis.



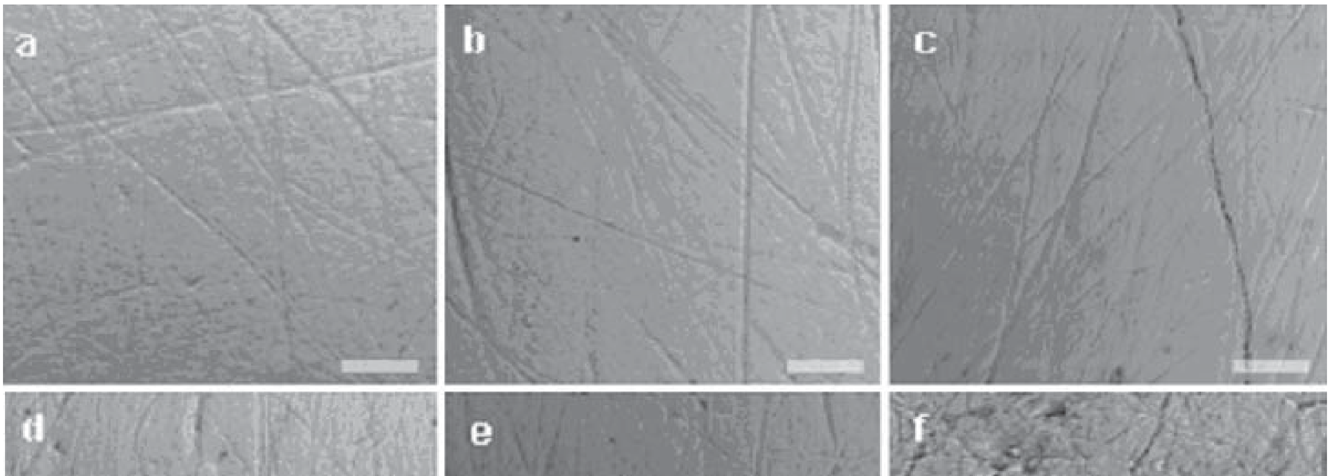


FIGURE 2. Selected micrographs of non-occlusal molar surfaces. Well-preserved buccal enamel areas used for the quantification of microwear patterns (a–e). Figures f and g show unpreserved enamel surfaces for the areas explored (see text) which were excluded from the analysis. Figures h and i show examples of parallel striation distribution caused by trampling effects. Bar: 100µm.

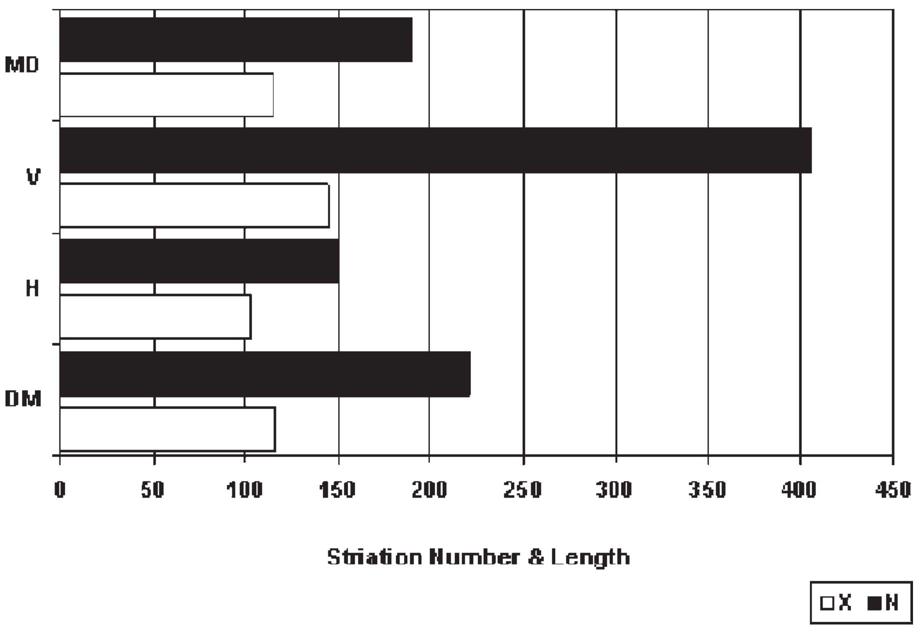


FIGURE 3. Histogram comparing the mean number of striations (N) and the average length (X) (in µm) by orientation categories (mean of groups). Following the model of Pérez-Pérez *et al.* 1994, orientation categories for lower, left molars are defined as follows: MD (mesio-occlusal to disto-cervical): 112.5–157.5º; V (vertical): 67.5–112.5º; H (horizontal): 0–22.5º and 157.5–180.0º and DM (mesio-cervical to disto-occlusal): 22.5–67.5º.

under the protoconid, hypoconid or between both cusps on the medial third of the buccal surface. Data analysis was conducted for individual images (one per individual) showing the best preserved enamel in the different micrographs obtained.

Micrographs (1.,280 x 9.60 pixels) were processed with Adobe Photoshop™ (version 6.0) resulting in an 8 bit digitised image of 0.56 mm^2 which was analysed using Microware 3.0 (Ungar 1995). Only linear striations =10µm with a length/width ratio of at least 4:1 were measured; fragments of striations crossed or broken by others were considered separately. No visible trampling features such as parallel distribution, fractures or curved scratches were considered (Martínez *et al.* 2001, Pérez-Pérez *et al.* 2003) (*Figure 2*). Striations were classified into four orientation categories, from 0º to 180º (in 45-degree intervals) (*Figure 3*). The number (N) and the average length (X) (in microns) of striations were recorded and classified by categories of orientation. Data analysis was conducted for individual micrographs and the results offered here are the mean for each group. Different variables obtained were compared and analysed using SPSS™ (version 11.0) for Windows™.

RESULTS AND DISCUSSION

The Kolmogorov-Smirnov normality test did not show significant deviation from Normality for the microwear density and length. Results are presented in *Table 2* and *Figure 3*. *Figure 2* shows selected micrographs relating to well-preserved enamel areas used in the study; unpreserved areas were excluded. Data from microwear quantification reveal differences between the groups examined. The mean of total striation number between groups indicates that Bronze Age Group 3 shows fewer and shorter microwear patterns than any of the other groups, and Group 2 shows higher and longer striations. By contrast, there is higher-order striation orientation distribution between groups. No significant age-related differences were found for the number of striations. Abrasive particles, both intrinsic and exogenous, on foods consumed are the potential cause of dental microwear formation processes. If the size and shape of microscopic features is related to the types of abrasives causing the wear, the size and density of microwear features will reflect the different amounts of abrasives in the food eaten. The data presented here show different microwear patterns from similar backgrounds and suggest relative differences in subsistence practices for the human groups examined.

Buccal microwear analysis applied to fossil hominids and bioarchaeological populations has suggested that interpopulation variability may yield valuable information about economic patterns and food processing techniques in the way that intra-group microwear density and average striation length is correlated with relative abrasion in the diet (Lalueza *et al.* 1996, Pérez-Pérez *et al.* 1994, 1999, 2003). Buccal microwear density from modern human hunter-gatherer groups ranged between 32.0 and 74.8 (Lalueza *et al.* 1996), lower than that of the bioarchaeological specimens examined in this study. In this respect, we can observe that the total number of striations decreased from bioarchaeological groups to carnivorous hunter-gatherers and the average feature length shows fluctuations. The purpose of these preliminary microwear results was to correlate the agriculturalist economic pattern (Pérez-Pérez *et al.* 1994) to that of modern hunter-gatherer economy (Lalueza *et al.* 1996), as non-occlusal dental microwear data based on ancient humans might require ancient models for dietary interpretations (Pérez-Pérez *et al.* 2003). Our results seem to sustain this hypothesis for the Bronze Age populations, but need to be confirmed with a large sample from a similar chronological period.

Bronze Age economies are based on agriculture and animal husbandry. Agricultural resources are characterized by cereals such as emmer wheat, barley, bread wheat, spelt wheat, millet derived from different regions, and cultivated legumes. The microwear patterns studied here showed relative differences among human groups; although these groups lived on a mixed subsistence economy diet, it is still possible – even within the same cultural background – to differentiate the different percentages of abrasiveness in the diet related to agricultural production, climatic inferences (Araus *et al.* 1997), or different processes applied to grain resources, which can provide important data on future inter-group comparisons of larger samples.

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