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The Bronze Age burials from Cova Dels Blaus (Vall d′Uixó, Castelló, Spain): An approach to palaeodietary reconstruction through dental pathology, occlusal wear and buccal microwear patterns

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Abstract

This paper reports a palaeodietary investigation of the human remains found in the collective Bronze Age burial cave from Vall d′Uixó (Castelló, Spain). Dental pathology, tooth wear as well as buccal dental microwear were analysed. Percentages of dental pathologies were compared with Chalcolithic and Bronze Age sites from the same territory. Dental caries, *ante-mortem* tooth loss, periodontal disease and abscess frequencies indicate a diet rich in carbohydrate foods. However, dental calculus percentages and macroscopic wear patterns suggest a diet not exclusively relying on agricultural resources. In addition, buccal dental microwear density and length by orientation recorded on micrographs using a scanning electron microscope showed inter-group differences with regard to carnivorous hunter-gatherers and farming populations related to the amount of abrasives in the diet that could

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correspond to a different dependence on agricultural resources or food preparation technology.

Resumen

Este artículo presenta una investigación de paleodieta de los restos humanos encontrados en la cueva de enterramiento colectivo de la Edad del Bronce procedente de la Vall d′Uixó (Castelló, España). La patología dentaria, el desgaste del diente así como el microdesgaste dentario vestibular fueron analizados. Los porcentajes de patología dentaria fueron comparados con yacimientos del Calcolítico y Edad del Bronce del mismo territorio. La frecuencia de caries, perdida dentaria *ante-mortem*, enfermedad periodontal y abscesos indican una dieta rica en hidratos de carbono. Sin embargo, los porcentajes de cálculo dentario y el patrón macroscópico de desgaste sugieren una dieta no exclusivamente relacionada con recursos agrícolas. Además, la densidad del microdesgaste dentario vestibular y su longitud por orientación registrada en micrografías empleando un microscopio electrónico de barrido mostraron diferencias inter-grupales con respecto a cazadores-recolectores carnívoros y poblaciones agrícolas relacionadas con la cantidad de abrasivos en la dieta que puede corresponder a una dependencia diferente en recursos agrícolas o técnica de preparación del alimento.

Introduction

In this paper, we present the results of bioanthropological and palaeonutritional study carried out on the Bronze Age burials found in the Cova dels Blaus (CDB) site in Vall d'Uixó, Castellón, Spain. CDB is a small karstic hollow lying 2 km Northwest of Vall d′Uixó, at an altitude of 120 m above sea level. This hollow covers part of the first foothills of the Espadán mountain range and offers a good view of most of the Plana de Castellón below, which extends to the Mediterranean Sea. The cavern consists of a small descending gallery approximately 11 m long and two and a half metres wide. At the back, the gallery is intersected by a second one, resulting in a hall nearly 6 m wide that shows signs of intense human occupation. Archaeological excavations have been carried out since 1987 and have been financially supported by the Conselleria d′Educació i Ciència (Generalitat Valenciana) within the scope of its standard programme of excavations. The stratigraphy shows the presence of a superficial level and five sublevels (Casabó, 2001). This paper presents the study of the necropolis phase, found in the 3rd level during the 1995 campaign.

Two main phases of occupation can be established at CDB (Casabó, 2001): the first one at the end of the Pleistocene and beginning of the Holocene, when the caves were inhabited by hunting-gathering societies, and the second one at the end of the 3rd Millennium or beginning of the 2nd Millennium BC. In this period the cavity was used as a necropolis for multiple inhumations, a funerary space reminiscent of the megalithic phenomenon in its arrangement and conception.

At CDB, the space within the cavern has been reorganised to fit with the concept of chamber and corridor. The skeletons lie, in the foetal position, with their heads oriented towards the entrance, and in total or partial articulation. Lithic industry and fragments of ceramic vessels were found associated with the skeletal remains. Although the contextual association of the material culture such as knives or arrow tips is dated to around the Chalcolithic period, typology of ceramic burial offerings indicates an Early Bronze Age burial date (Casabó, 2001; Polo and Casabó, 2004).

In the Valencian territory, the Bronze Age is a prehistoric period that has not yet been extensively analysed from a bioanthropological point of view, especially with regard to palaeodiet (Cloquell and Aguilar, 1996; Cloquell et al., 2001). In this respect, CDB represents a funerary group that has provided information about the first hierarchically structured societies in the Levant (Casabó, 2001).

Material and methods

At least 9 inhumations were documented (6 adults and 3 children). The number of permanent teeth recovered for the adult human sample was 110 (39 *in situ* and 71 isolated).

Unfortunately, most of the adult skeletons had poorly preserved cranial or pelvic structures. For this reason, sex was mostly determined using the postcranial skeleton (Moore-Jansen et al., 1994; Rose et al., 1991), some mandibular remains (Moore-Jansen et al., 1994) and estimated with mathematical discriminate functions (Alemán et al., 1997). In this way, it was determined that the six adult skeletons belonged to four females (CDB4, 5, 6 and 9), a male (CDB2) and an individual of unknown sex (CDB3). The ages at death were determined to be between the 20 and 35 years. The ages at death among children ranged between the first and the fourth year of life.

Examination of dental pathology was carried out for the adult human sample. This included dental calculus, caries, periodontal disease, enamel hypoplasia, *ante-mortem* tooth loss and abscesses. In order to determine the type of food eaten and the effect of abrasive particles on teeth during food processing we also examined gross dental wear (Smith, 1984) and microwear on the non-occlusal (buccal) surfaces of the molar teeth.

Mandibular second permanent molars from the adults were examined for buccal microwear using scanning electron microscopy. The mandibular molar was selected for reasons of standardisation. Previous studies have shown that buccal microwear should preferably be studied from lower molar teeth (Lalueza et al., 1996; Pérez-Pérez et al., 1994).

The enamel was cleaned with acetone, ethanol and air-dried. The proximal halves of the buccal surfaces were examined using a scanning electron microscope Hitachi S-3000N in variable pressure using a high-energy back-scattered electron emission mode (Romero et al., 2002). Specimens were scanned at a magnification of 100 ×, at 20 kV, and at a working distance ranging between 9 and 11 mm in order to take pictures. Micrographs (BMP file format) were processed with Adobe Photoshop™

(version 6.0) resulting in an 8 bit digitised image of 0.56 mm^2 (Pérez-Pérez et al., 1999) (Fig. 1) which was analysed using Microware 3.0 (Ungar, 1995) in Windows 95. The total number of striations (NT) (microwear density) and their average length (XT) in micrometres (μm) were recorded and classified into four orientation categories from 0° to 180° (in 45° intervals) (Pérez-Pérez et al., 1994) for left lower molars as follows: mesio-distal (MD): 112.5–157.5°, V (vertical): 67.5–112.5°, H (horizontal): 0–22.5° and 157.5–180.0° and, disto-mesial (DM): 22.5–67.5°.

Intra- and inter-group dental pathology and buccal microwear variability were analysed. The frequency of dental pathology, comparing the number of teeth with pathologies with the number of teeth examined, obtained from CDB was compared to other Chalcolithic and Bronze Age populations from Alicante and Castellón (Valencian territory) (Cloquell, 1994; Cloquell and Aguilar, 1996; Cloquell et al., 2001) using the same criteria. On the other hand, CDB buccal microwear pattern (NT and XT variables) was compared for this group and a series of modern hunter-gatherers with different diets and ecological conditions (Lalueza et al., 1996) and an ancient agro-pastoralist population (Pérez-Pérez et al., 1994). All statistical tests were conducted using SPSS (version 10.0), and the graphs were created with SYSTAT (version 11.0). The frequency (%) of dental pathology was calculated for each sex from CDB and the differences between sexes were compared using Student's *t*-test. Due to non-normal distribution of some variables (Kolmogorov–Smirnov normality test) ($p < 0.05$), non-parametric Kruskall–Wallis test ($p < 0.05$) was used to

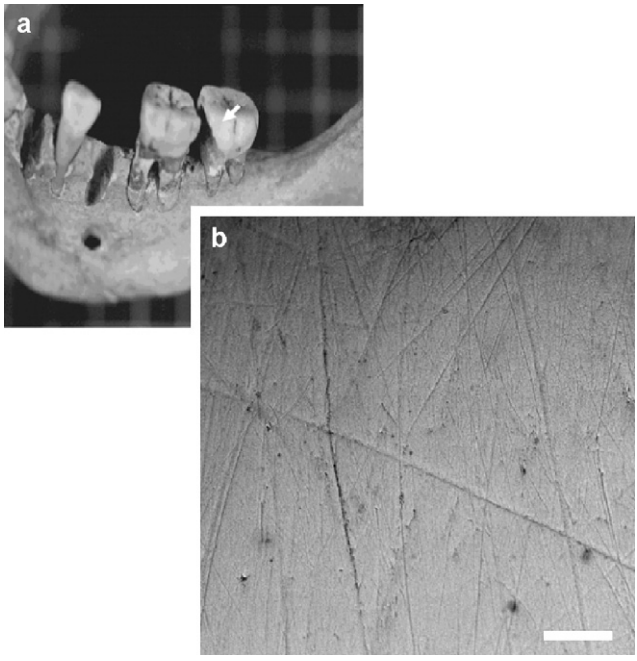

Fig. 1. Buccal view of an adult male mandible-CDB2 (a). Buccal surface electron micrograph (scale bar: 100 μm) (b). Preferential striations orientation and their lengths can be observed.

compare the differences of the proportions of altered teeth (in relation to observed teeth) and to compare buccal microwear variability among human groups.

Results

Dental pathology results from CDB are presented in Fig. 2. Table 1 shows percentage frequency of dental pathology from CDB compared (Kruskall–Wallis test) with various Chalcolithic and Bronze Age sites from Valencian territory (east Spain). Intra- and inter-group buccal microwear variability are presented in Fig. 3.

Dental pathology

The only significant difference between sexes in the frequency of dental pathology (CBD intra-group dental pathology frequency) was observed in the *ante-mortem* tooth loss ($t = 4.91$, $p < 0.01$) (Fig. 2). The only male recovered (CDB2) showed a higher prevalence of *ante-mortem* tooth loss and caries (2.72%) than females (0.22% of *ante-mortem* tooth loss and 0.68% of caries). However, a similar prevalence of caries ($t = 0.44$, $p < 0.44$) and enamel hypoplasia ($t = 0.25$, $p < 0.81$) was observed in both sexes. On the other hand, periodontal disease was observed among 50% (CDB3, 5 and 9) and abscesses in 33.3% (CDB4 and CDB 5) of individuals.

These results suggest, despite the small sample size analysed, intra-group differences in dental pathologies related to homogeneous foodstuffs consumed within a sex subgroup. However, as indicated by Cloquell (1994), due to the fragmentary and small sizes of prehistoric populations (4th–2nd Millennium BC) recovered from Valencian territory, only inter-group comparisons showed valuable information about disease status.

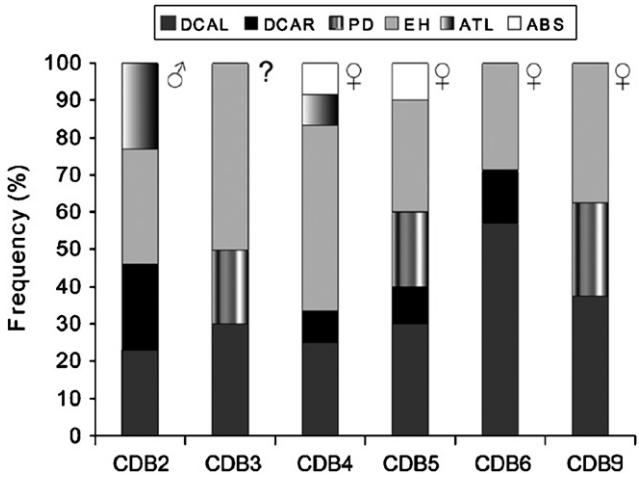

Fig. 2. Intra-group frequencies (adult sample) of dental pathologies from CDB population.

Table 1. Percentage frequency of dental pathology (teeth with lesions in relation to observed teeth) between Chalcolithic and Bronze Age sites including Cova dels Blaus (CDB) (E Spain)

	Chalcolithic		Bronze Age		
	Masadeta Cave (MC)	Vinalopó Valley (VC)	Castellets Cave (CC)	Vinalopó Valley (VB)	CDB
N Teeth	206	1283	227	446	110
DCAL	23.3[a]	40.3[b]	26.4[h]	40.5[b]	17.3
DCAR	5.8	6.9[c]	17.1[i]	8.9[c]	5.4
PD	0.9	13.8[d]	13.2	18.3[d]	15.4[j]
EH	13.1	20.4[e]	22.9	23.3[e]	20.9
ATL	–	6.2	0.4	3.3	10.2[f]
ABS	–	1.4	–	3.1	5.1[g]

[a]MC significantly greater than CDB ($p<0.005$).
[b]VC and VB significantly greater than CDB ($p<0.000$).
[c]VC and VB significantly greater than CDB ($p<0.000$).
[d]VC and VB significantly greater than CDB ($p<0.000$ and $p<0.003$).
[e]VC and VB significantly greater than CDB ($p<0.000$).
[f]CDB significantly greater than VC and VB ($p<0.000$ and $p<0.011$).
[g]CDB significantly greater than VC and VB ($p<0.004$ and $p<0.002$).
[h]CC significantly greater than CDB ($p<0.001$).
[i]CC significantly greater than CDB ($p<0.000$).
[j]CDB significantly greater than CC ($p<0.000$).

Of the teeth from CDB, 5.4% had dental caries (Table 1). This prevalence is slightly lower than that observed in other Bronze Age caves located in the geographical region of Castellón, like Cova dels Castellets in Artana (Castellón), where the prevalence is 17.1% ($\chi^2 = 10.39$, $p<0.001$), and the populations of the Vinalopó Valley (Alicante), where the prevalence is 8.9% ($\chi^2 = 8.63$, $p<0.003$). Conversely, the value is close to the one obtained in Cova Masadeta, also in Artana, where the prevalence is 5.8% ($\chi^2 = 0.28$, $p<0.6$).

Dental calculus was present on 17.3% of the teeth examined. This percentage from CDB is lower than that obtained in Cova dels Castellets (26.4%) ($\chi^2 = 10.39$, $p<0.001$) and Cova Masadeta (23.3%) ($\chi^2 = 7.90$, $p<0.005$). We believe that these data are important in discerning a certain economic pattern in CDB.

The presence of deficiencies in enamel thickness (enamel hypoplasia) (Hillson and Bond, 1997) was observed on 20.9% of the teeth examined, predominantly in the central incisor and canine teeth and, with a lesser frequency in the molars. Hypoplastic defects were most frequently formed between the 4th and 6th year of life (Reid and Dean, 2000). These data are similar to the results obtained in the Caves dels Castellets and Masadeta, where 82% of the hypoplasia developed between the 4th and 6th year of life (Cloquell et al., 2001). The overall prevalence is also very close to the Bronze Age groups in Castellets and Vinalopó Valley (Alicante) (Table 1).

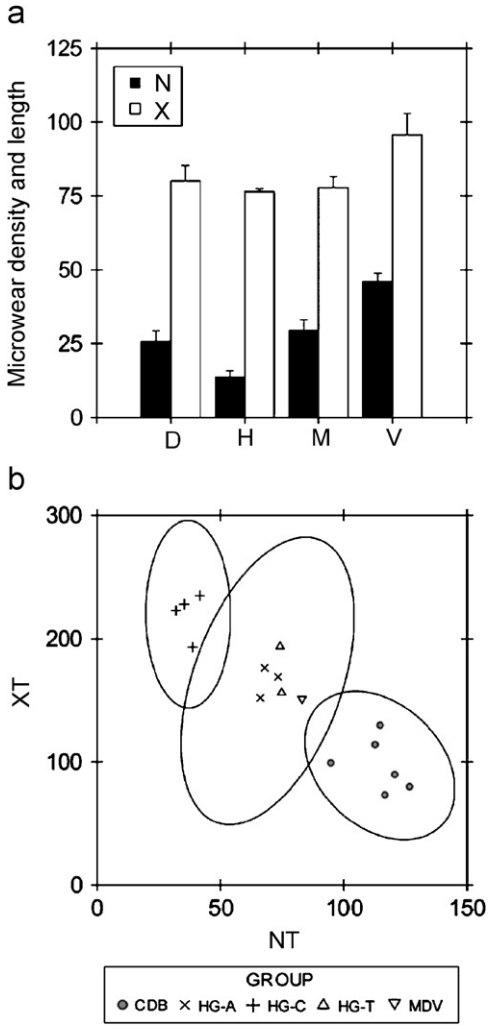

Fig. 3. Histogram comparing average values of total striation number (N) and length (X) (in μm) by orientation categories (intra-group values) (a). Plot of striation density (NT) versus striation average length (XT) (in μm) from different populations (b): medieval population (MDV) (Pérez-Pérez et al., 1994), hunter-gatherers from tropical forest (HG-T), hunter-gatherers from arid environment (HG-A), carnivorous hunter-gatherers (HG-C) (Lalueza et al., 1996) and Cova dels Blaus (CDB). The ellipses include 85% confidence regions of the samples compared.

Severe bone resorption in the alveolar crests (2–4 mm) was seen in 15.4% of the adult human sample indicating periodontal disease (Clarke et al., 1986). As with the enamel hypoplasia, the degree of periodontal disease was close to the average documented in Castellets and the populations of Vinalopó Valley (Alicante). On the

other hand, *ante-mortem* tooth loss in CDB (10.2%) was much higher than that observed in the populations of the Vinalopó Valley (3.3%) ($\chi^2 = 6.53$, $p < 0.011$).

Finally, two individuals from CDB showed signs of oral infectious pathology in the form of abscesses. The prevalence of abscesses (5.1%) was higher than that observed in the populations of the Vinalopó Valley (Alicante) ($p < 0.05$).

Dental wear and microwear

CDB occlusal wear is not very marked (Smith, 1984). Only 6.3% of the teeth were worn in the 7–8 degrees, 18.1% in the 5–6 degrees, whilst 75.6% had lower degrees of wear, ranging from 1 to 4. This type of wear has been associated with abrasive diets of a vegetable type rich in carbohydrates (most likely cereals) (Kieser et al., 2001; Powell, 1985) though it can also be associated with pathologies such as bruxism (Khan et al., 1998). In general the occlusal wear was low; as would be expected among individuals who died in their third decade of life.

CDB buccal dental microwear results showed a mean number of 114.66 (SD = 10.83) striations with an average striation length of 99.6 μm (SD = 55.7). As shown in Fig. 3a, buccal striation distributions exhibit high number of striations with mesio-distal (29.1% NMD), vertical (39.8% NV) and disto-mesial (22.8% NDM) orientation rather than with horizontal orientation (11.9% NH). In addition, vertical striations are longer (XV = 112.35, SD = 30.48 μm) than other striations by orientation categories (range between 76.43 and 90.77 μm) similar to the results presented in previous intra-group buccal microwear studies (Pérez-Pérez et al., 1994, 1999; Romero et al., 2002).

Inter-group CDB microwear variability (Fig. 3b) shows high values of feature density (NT) and lower average length (XT) than observed in other hunting groups (NT; $\chi^2 = 12.75$, $p < 0.005$ and XT; $\chi^2 = 12.05$, $p < 0.007$). Feature density in modern hunter-gatherer groups ranges between 32.0 and 74.8 with an average length between 152.0 and 235.2 μm (Lalueza et al., 1996). On the other hand, buccal-microwear results from a medieval agriculturalist population have shown a mean striation number of 83.1 and an average striation length of 151.2 μm (Pérez-Pérez et al., 1994) exhibiting more homogeneous microwear pattern as compared to the CDB sample.

Discussion

Comparison of the results of previous dental pathology studies concerning Bronze Age samples from the Spanish Mediterranean area (Cloquell and Aguilar, 1996; Cloquell et al., 2001) with those reported here from CDB, revealed little change in the frequency of periodontal disease and enamel hypoplasia, whilst dental caries and calculus at CDB are clearly less prevalent than in other Chalcolithic and Bronze Age populations from Eastern Spain.

Some of the dental pathologies in Bronze Age Vinalopó Valley may be explained by the amount of carbohydrates in the diet from different types of agricultural

resources, but their percentage is difficult to establish and may have differed in nearby areas and over different Bronze Age phases (Buxó, 1997; Castro et al., 1999). The low incidence of caries in CDB may indicate that their diet was highly abrasive. However, the low percentage of calculus may suggest that the diet in CDB was not exclusively based on carbohydrates (Lieverse, 1999).

On the other hand, buccal microwear analysis applied to fossil hominids and other bioarchaeological samples has suggested that inter-population variability may yield valuable information about economic patterns and food processing techniques (Lalueza et al., 1996; Pérez-Pérez et al., 1994, 1999, 2003; Romero et al., 2002).

Using buccal dental microwear analysis, great differences have been found between modern hunting groups and Neandertals because of the fact that, on abraded surfaces, the average length of the striations decreases when their number increases (Pérez-Pérez et al., 2003). On the other hand the increase in pitting, seen in a microscopic examination of the molar occlusal surface, among different populations supports the hypothesis that there is an association of the pitting with the consumption of hard foods (Schmidt, 2001; Teaford et al., 2001). Although, microscopic examinations of occlusal and non-occlusal surfaces clearly show different microwear patterns (Pérez-Pérez et al., 2003).

Siliceous phytoliths in plant structures or exogenous grit might then be associated with presence of microfractures in enamel (Gügel et al., 2001; Lalueza Fox et al., 1994) but, unfortunately, the association between types of particles and the microwear pattern has not yet been explained (Rose and Ungar, 1998). Nevertheless, if microscopic features are related to abrasive particles in foodstuffs, the relative differences in inter-group microwear patterns can reflect the abrasive nature of the diet. Microwear density from modern hunter-gatherers (Lalueza et al., 1996) shows less abraded buccal surfaces than that of the agriculturalist populations (Pérez-Pérez et al., 1994) and the Bronze Age group in this study. An early report has shown that buccal dental microwear data based on ancient humans might require ancient models for dietary interpretations (Pérez-Pérez et al., 2003). Thus, our results need to be confirmed with a study of a large sample from a similar chronological period.

Chalcolithic and Bronze Age economies are based on agriculture and animal husbandry (Buxó, 1997; Del Rincón, 1998). Agricultural resources, characterised by cereals such as emmer wheat, barley, bread wheat, spelt wheat, millet derived from different regions and cultivated legumes, were an important component in the Bronze Age diet (Buxó, 1997; Castro et al., 1999; Del Rincón, 1998). Opal phytoliths in cereals and the residues from grinding of seeds using stone mills are the most abrasive particles in human food (Gügel et al., 2001; Pérez-Pérez et al., 1994). High striation enamel density in CDB suggests a more abrasive diet than in modern hunter-gatherers. This high density in the agriculturalist population probably derived from different food processing methods rather than from the amount of plant foods consumed.

Summarising, our results seem to support the subsistence economy hypothesis for the Bronze Age populations located in Castellón areas (Eastern Spain) suggesting an agriculturalist and pastoralist lifestyle (Del Rincón, 1998, p. 292). These groups

based their subsistence on cereal agriculture combined with the use of domesticated animals for meat consumption, as a major source of food.

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