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Calculus, periodontal disease and tooth decay among the prehispanic population from Gran Canaria

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Abstract

In the prehispanic Gran Canaria there are some anthropological differences between the coastal inhabitants who buried their dead mainly in tumuli, and those from the central mountains, mainly buried in caves. Some data, as the prevalence of auricular exostoses, and a different bone Ba/Sr ratio support the view that there were differences in economy and diet between both groups of islanders. Moreover, the proportion of carious teeth was significantly higher among the population buried in caves. In the present study we analysed the prevalence of dental calculus, periodontal disease and antemortem tooth loss in remains of 791 individuals belonging to the anthropological collection of the Museo Canario (Las Palmas). Calculus deposition was very frequent (88.51%), no differences existing between men and women or between those interred in tumuli or in caves. Age at death was the only parameter independently related to calculus deposition by stepwise multivariate analysis. Periodontal disease was observed in 66.78% of the population, significantly more in men ($\chi^2 = 4.88$, $P = 0.027$). No differences existed between individuals buried in tumuli and in caves. Antemortem teeth loss was observed in 64.73% of individuals, no differences existing between men and women or between those interred in tumuli or in caves. There was a significant association between calculus and periodontal disease ($\chi^2 = 18.07$, $P < 0.0001$). Both caries ($\chi^2 = 8.40$, $P = 0.004$) and periodontal disease ($\chi^2 = 44.96$, $P < 0.0001$) were associated with tooth decay. However, the proportion of teeth with calculus deposition (in relation to observed teeth) was significantly higher among the population buried in tumuli ($Z = 3.18$, $P = 0.001$), although no differences were observed when the proportion of antemortem lost teeth and alveoli with periodontal disease were compared among people buried in tumuli and in caves, but women showed significantly lower proportions of alveoli with periodontal disease and antemortem tooth decay. These data suggest that the population buried in caves had a different dietary pattern to that of those buried in tumuli, since calculus deposition -more frequent in the latter-may be related to the consumption of proteins. The results also point to the existence of differences in diet between men and women.

Keywords: Paleonutrition; Caries; Calculus; Periodontal disease; Tooth decay; Gran Canaria ancient; Canary Islands ancient

1. Introduction

The island of Gran Canaria is one of the seven "big" islands of the Canary Archipelago, which is situated in front of the Sahara coast, at a latitude 27–29° North. Although many uncertainties exist, the Canary Archipelago was colonized in prehispanic times by people of North African origin who arrived at the islands towards the second half of the 1st

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millennium BC [21], a hypothesis which has been reinforced in recent times by data provided by genetic studies [18,22,23].

Strong differences exist between the archaeological remains of the different islands. However, remains from Gran Canaria lend support to the existence of a protourban society, adapted to the special geoclimatic conditions of the island, an abrupt landscape with central mountains reaching nearly 2000 m altitude. Among the remains, there are two strikingly different burial types. The inhabitants of the central highlands buried their dead in huge collective burial caves; dead were not interred, but deposited on stony or plant layers. On the contrary, in coastal areas, although not exclusively, interments are in tumuli. The significance of these two types of interments is unknown. The prehispanic society from Gran Canaria was strongly hierarchized. Perhaps, individuals interred in tumuli belonged to higher social class that those buried in caves.

The island, with an area of ca. 1500 km^2, was inhabited by nearly 50,000 individuals with a population density of 30 inh/km^2 at the time of the Spanish conquest. This demographic pressure surely had a negative counterpart. The economy was mainly based on agriculture and some cattle raising and fishing. This last economic activity was practised by coastal people, as the chroniclers wrote [20], and should have contributed little to the economy of the island. In contrast, agriculture was the main source of edible products. Agricultural surplus of the good years was kept in huge silos to be distributed by the landlords in years of bad yield [20]. Indeed, the subdesertic climate leads to irregular and scarce rainfall, and vicinity to the Sahara desert and Sahel facilitated the arrival from locust plagues which almost certainly devastated the fields (repeatedly documented since short after Spanish conquest [3]). This would almost certainly have been followed by widespread malnutrition. In accordance with this hypothesis, we have shown a high prevalence of osteopenia among the inhabitants of this island, in both pelvis [7] and tibiae [30], a finding possibly explained by a poor nutritional status. Also, the proportion of adult individuals who died at young ages was strikingly high [7,30].

Previous studies have shown that prevalence of auricular exostoses is higher among the population interred in coastal tumuli compared with the inland population [29]. This finding may be explained by the practice of marine activities, something supported by chroniclers reports, by archaeological data [24] and by the finding of a bone Ba/Sr ratio of the individuals buried in the coastal regions significantly lower than that of the individuals buried in inland caves, although both groups showed a high bone strontium content [7]. A low Ba/Sr ratio may indicate consumption of a diet based on marine products [2]. In addition, we found that the prevalence of caries is quite lower among the population buried in coastal interments than in those individuals buried in caves [5], a finding which also suggests the consumption of less carbohydrate [9,13,17,27] by the inhabitants of the coastal areas. Thus, it seems that people from the coastal areas showed a quite different dietary pattern than people from central highlands.

Dental calculus is composed of inorganic components, including several calcium phosphate salts and an organic matrix formed by salivary proteins, cell debris, and bacteria which adhere to the new surface [10]. Activated leukocytes and macrophages may produce calcium binding proteins [12] which lead to plaque mineralization given supersaturation of saliva and plaque fluid with respect to calcium phosphate. Salivary flow rate and pH may influence saturation of calcium phosphate salts. Undoubtedly, diet modifies salivary pH and salivary flow, and also provides calcium phosphate salts. Therefore, assessment of the prevalence of dental calculus in prehistoric and living populations may inform about dietary habits [16,17,31,32]. However, uncertainty exists with respect to which specific dietary component(s) underly the formation of calculus.

Calculus may harbour pathogenic bacteria which may lead to preriodontal disease. Some of these bacteria, notably Actinobacillus actynomycetemcomitans, are capable of inducing bone loss, leading to alveolar bone resorption and tooth decay [34]. Both parameters can be easily recorded in ancient remains. Based on these facts, the aim of our study is to assess the prevalence and intensity of calculus deposition, periodontal disease, and antemortem tooth loss among the prehispanic population from Gran Canaria, specifically looking for differences between individuals buried in tumuli or in caves.

2. Materials and methods

2.1. Sample

The sample analysed in this study belongs to the anthropological collection of the Museo Canario (Las Palmas). Maxilla, mandibles, or complete crania of a total of 791 individuals buried either in the central highlands (as Guayadeque) of Gran Canaria or in coastal burial sites were included in the study (Fig. 1). Guayadeque is a ravine located in the eastern mountains of the island, in which several collective burial caves contain remains of hundreds of individuals, whose corps were deposited on plant or stony layers. It is by far the most important funerary site from Gran Canaria. Absolute dates (Table 1) for some remains from Guayadeque yield time depths ranging from 1213 ± 60 to 1410 ± 60 BP [19]. El Agujero is the most important tumular interment from Gran Canaria, containing the remains of several dozen well-preserved individuals. Dates available for the samples from El Agujero yield a time depth of 875 ± 60 BP. According to radiocarbon dating we further classified our sample in three degrees of antiquity: those who died more than 1500 years ago, those who died between 1000 and 1500 years ago, and the most recent ones, who had died between 500 and 1000 years ago.

Sex was estimated by considering the classic macroscopic aspects of the skull and jaws [28]. Following this method, 407 individuals were men, and 216 were women. In the remaining cases either sex could not be accurately estimated from the macroscopic features or preservation of the remains did not allow sex estimation. Age at death was established following Brothwell's criteria [1] on dental attrition, classifying the sample into 4 stages according to age at death (17–25 years, 25–35,

Fig. 1. Map of the island Gran Canaria with the main burial sites (*tumuli*).

35–45 and 45+). This parameter could be recorded in 594 individuals. As reported elsewhere [5], we have tested the validity of Brothwell's method for the population of Gran Canaria, analysing the intensity of wear affecting the first and second molar teeth in 35 individuals with intact third molars. Based on the intensity of wear at the third molar we further calculated the age at death of the individuals of our sample.

In this sample we have already described a high prevalence of individuals with at least one carious teeth, a proportion which is significantly higher among the individuals buried in caves (66.95%) than among those buried in tumuli (58.91%). A similar difference was also described when the proportion of teeth with carious lesions in relation to observed teeth was compared between individuals buried in caves and those buried in tumuli [5].

2.2. Methods

The following criteria were recorded:

(a) Number of observed teeth.
(b) Number of teeth with calculus deposition (Fig. 2), either supragingival or subgingival.
(c) Number of dental alveoli with evidence of periodontal disease. Periodontal disease was defined when resorption of the alveolar crests and/or of the alveloar interdental septae was observed, together with a distance greater than 3 mm between the alveolocemental line and the eroded alveolar crest (Fig. 3). Both criteria are required, since the mere inspection of apparent alveolar recession may also misclassify super eruption due to attrition [11].
(d) Number of antemortem lost teeth. The following criteria should be present to identify an antemortem lost tooth: 1. Shallowing of the socket; 2. A dull alveolar margin (Fig. 4).

Table 1
Available radiocarbon dates

Subsample	Dates (BP ± SD)
Guayadeque	1120 ± 60
Guayadeque	1410 ± 60
Cuevas del Rey	1665 ± 60
Acusa	1380 ± 60
Acusa	1520 ± 45
Agujero	875 ± 60
Caserones	1140 ± 100
Metropole	540 ± 70
Guayedra	700 ± 50
La Restinga	1030 ± 110
Túmulos Agaete	950 ± 40
Hormiguero	1740 ± 90

Fig. 2. Calculus deposition (left, slight; right, severe).

We calculated:

(a) The proportion of individuals with at least one tooth with calculus deposition, with at least one alveolus with periodontal disease and with at least one tooth lost antemortem.
(b) The number of teeth with calculus deposition, the number of alveoli with preriodontal disease, and the number of antemortem lost teeth for each individual.
(c) The proportion of teeth with each of the aforementioned alterations (in relation to the observed alveoli) for each individual.

2.3. Statistics

Proportions of individuals with the aforementioned alterations were compared between men and women, between individuals buried in caves or in tumuli, or with different ages at death by means of the Chi-squared test (with Yates correction in 2×2 tables). This test was also used, in general, when two qualitative parameters were compared. We also calculated the mean proportion of teeth (in relation to observed teeth) with each of the aforementioned alterations in men and women, in individuals buried in caves or in tumuli, and compared them by means of the Student's *t* test. Due to non-normal distribution of some variables, non-parametric tests as Kruskall–Wallis and Mann–Whitney tests were used to compare the differences of the proportions of altered teeth (in relation to observed teeth) in individuals with different ages at death or with different antiquity, in men and women, or individuals buried in caves or tumuli. Stepwise multiple correlation analyses were also performed in order to discern which of the following parameters: age at death, gender, burial type (cave or tumuli), or time depth exert significant effects on the proportion of teeth or alveoli with calculus, periodontal disease or antemortem decay. Also,

Fig. 3. Periodontal disease, with teeth also showing subgingival calculus deposition.

Fig. 4. A case of extreme antemortem teeth loss.

stepwise binary logistic regression analyses were performed to discern which factors (sex, age at death, burial type, or antiquity) were independently related with the presence or not of each of the analysed alterations in a given individual.

3. Results

3.1. Prevalence of individuals with teeth alterations

The prevalence of individuals with calculus deposition among the population analysed reached 88.51% (Table 2). A similar prevalence was observed in both sexes (89.10% among men and 90.31% among women, $\chi^2 = 0.20$, $P = 0.77$). We failed to find any differences between the prevalence of individuals with calculus deposition buried in tumuli (91.38%) and those buried in caves (87.95%, $\chi^2 = 1.12$, $P = 0.34$). The proportion of individuals with calculus deposition was highest among those who died between 25 and 35 years (96.37%) and among those who died between 35–45 years (98.48%), and lowest among those who died at older ages (73.08% among those aged 45+).Those who died between 17 and 25 years showed a prevalence of 89.20%. These differences were highly statistically significant ($\chi^2 = 40.77$, $P < 0.001$, Table 3). No association was observed between the prevalence of individuals with calculus deposition and antiquity ($\chi^2 = 1.63$, $P = 0.44$).

Periodontal disease was observed in 66.78% of the population (Table 2). No differences were observed between those buried in caves (66.60%) and those buried in tumuli (67.74%, $\chi^2 = 0.05$, $P = 0.83$). There was, however, a higher prevalence of periodontal disease among men (72.47%) than among women (62.79%, $\chi^2 = 4.88$, $P = 0.027$). Prevalence of periodontal disease was much lower among the youngest individuals (43.0%) than among those who died at older ages, among whom the prevalence was higher than 80% (Table 3). No association was found between periodontal disease and antiquity ($\chi^2 = 0.04$, $P = 0.98$).

There was evidence of antemortem teeth loss in 64.73% of individuals (Table 2). The proportion among those buried in tumuli (63.78%) was similar to that observed among those buried in caves (64.91%, $\chi^2 = 0.06$, $P = 0.81$). No differences were observed between men (64.62%) and women (64.35%, $\chi^2 = 0.004$, $P = 0.95$). There were marked differences among those who died between 17 and 25 years (32.39%) and those who died at 45 + years (95.90%, Table 3, $\chi^2 = 136.57$, $P < 0.001$), but no association was observed between antemortem tooth loss and antiquity ($\chi^2 = 3.92$, $P = 0.14$).

A significant association was observed between the presence of calculus and periodontal disease ($\chi^2 = 18.07$, $P < 0.001$). Periodontal disease was observed among 68.90% of individuals with calculus deposition, but only in 37.21% of those without calculus deposition. Also, prevalence of calculus deposition was lower (83.94%) among those without dental caries than among those with at least one carious tooth (90.85%, $\chi^2 = 7.62$, $P = 0.006$).

Calculus deposition was not associated with antemortem teeth loss. Both the presence of at least one carious lesion ($\chi^2 = 8.40$, $P = 0.004$) and, especially, periodontal disease ($\chi^2 = 44.96$, $P < 0.001$) were strongly associated with antemortem teeth loss.

Using stepwise logistic regression analysis we found that age at death was the only parameter related with calculus deposition ($B = -0.47$, Wald = 4.80, $P = 0.027$). A similar result was observed when this analysis was performed only in the population buried in tumuli ($P = 0.029$), whereas no relation with age at death (or with any other parameter) was observed when only the population buried in caves was analysed.

Using the same approach, the presence of periodontal disease was dependent on age at death (B = −1.40, Wald = 37.53, $P < 0.001$), calculus deposition ($B = 2.12$, Wald = 6.89, $P = 0.009$) and presence of caries ($B = 1.13$, Wald = 13.08, $P < 0.001$), in this order, a result which was also observed when those interred in caves were analysed separately, although in the stepwise analysis age at death entered first ($P < 0.001$), followed by caries ($P = 0.001$) and calculus deposition ($P = 0.005$). Finally, antemortem teeth loss was dependent on age at death (B = −0.95, Wald = 30.03, $P < 0.001$) and presence of caries ($B = 0.99$, Wald = 11.62, $P = 0.001$). An identical significance of these two parameters were observed when the analysis was performed on those interred in caves, whereas only age at death was related with antemortem teeth loss in those buried in tumuli ($B = 1.7$, $P = 0.01$).

Table 2
Proportion of individuals with at least one affected teeth, buried in caves or in tumuli

	Caves		Tumuli	
	Men	Women	Men	Women
Teeth with calculus	256/288	155/171	64/71	19/21
Periodontal disease	182/251	96/151	40/57	11/17
Antemortem teeth loss	202/321	129/190	54/77	8/21

Table 3
Prevalence of individuals with and without tooth lesions according to age at death

Age at death	With calculus	Without calculus	With periodontitis	Without periodontitis	Antemortem loss	
					Yes	No
17–24 years	190	23	89	118	69	144
25–35 years	186	7	147	35	106	87
35–45 years	65	1	54	9	49	17
45 + years	57	21	36	8	117	5

3.2. Proportion of teeth with pathological changes

The proportion of teeth with calculus deposition reaches 62.81% (4227 out of 6730 teeth, Table 4). Subgingival calculus

Table 4
Calculus deposition for each tooth type

Maxilla			Mandible	
Tooth Maxilla	Observed	Calculus	Observed	Calculus
I1	130	55	170	139
I2	205	107	245	198
C	293	158	327	263
P3	486	195	463	333
P4	473	220	434	296
M1	659	461	704	452
M2	571	370	645	406

deposition was less frequently observed (in 1687 teeth, 25.07%), without gender differences (24.22% of the teeth which belong to women and 25.16% of those belonging to men).

Differences in the proportion of teeth with calculus deposition (in relation to the observed teeth) between the population buried in caves and that buried in tumuli are statistically significant ($Z = 3.18$, $P = 0.001$, Table 5). The median proportion of teeth with calculus deposition was higher among the population buried in tumuli (median = 80%; interquartile range (IR) = 50–99.22%) than among that buried in caves (median = 61.11%; IR = 33.33–87.50%).

Globally, differences in the proportions of teeth with calculus deposition between men (median = 66.67%; IR = 40–90%) and women (median = 60%; IR = 33.33–84.29%) were not statistically significant ($Z = 1.65$, $P = 0.099$). However, 2574 teeth out of 3843 (66.98%) which belonged to men, but only 1034 out of 1796 (57.57%) teeth which belonged to women, were affected by calculus deposition, a difference which was statistically significant ($\chi^2 = 47$, $P < 0.001$). There were differences in the proportion of teeth with calculus deposition among the individuals of the 4 groups of ages at death (KW = 28.31, $P < 0.001$) (Table 6), but there were no differences in the proportion of teeth with calculus deposition among the individuals according to antiquity (KW = 4.54, $P = 0.104$; median proportion of the most antique individuals = 66.67%; IR = 33.33–85.71%; median proportion of the most recent individuals = 80%; IR = 50–100%).

A total of 1349 out of 6507 (20.7%) alveoli were affected by periodontal disease, especially the posterior teeth (1142 out of 4402, 25.94% vs 207 out of 2105, 9.83%, $\chi^2 = 224.87$, $P < 0.001$).

No differences were observed among individuals buried in caves and those buried in tumuli regarding proportion of teeth with periodontal disease and proportion of antemortem lost teeth. However, proportion of alveoli with periodontal disease was higher among men (median = 25; IR = 0–50%) than among women (median = 14.83%, IR = 0–40%, $Z = 2.56$, $P = 0.01$). This difference was also observed among the people buried in caves ($Z = 2.29$, $P = 0.02$), but not among those buried in tumuli (Table 5). Also, the absolute proportion of alveoli with periodontal disease was much higher among alveoli belonging to men (846/3611, 23.43%) than among those belonging to women (314/1884, 16.67%, $\chi^2 = 33.99$, $P < 0.001$). No differences were observed between men and women with respect to antemortem teeth loss in the total population and in the population buried in caves. However, among those buried in tumuli, women showed a lower proportion of antemortem teeth decay (median = 0, IR = 0–6.90%) than men (median = 9.38%, IR = 0–30.44%, $Z = 2.95$, $P = 0.003$). Antiquity was also not related with proportion of alveoli with periodontal disease and antemortem lost teeth.

Marked differences were observed when the proportion of alveoli with periodontal disease was compared among the age-at-death groups (KW = 116.99, $P < 0.001$, Table 6), a result which was also observed when only individuals buried in caves (KW = 97, $P < 0.001$) and only individuals buried in tumuli were considered (KW = 16.31, $P = 0.001$). In a similar way proportion of antemortem lost teeth was much higher in the elderly individuals (KW = 291.25, $P < 0.001$, Table 6) both among those buried in caves (KW = 228.75) and in tumuli (KW = 54.37, $P < 0.001$ in both cases).

There was a significant relationship between the proportion of teeth with calculus deposition and the proportion of teeth with periodontal disease ($r = 0.26$, $P < 0.001$), but not between the proportion of teeth with calculus deposition and antemortem loss of teeth ($r = 0.06$, $P = 0.13$), or the proportion of carious teeth ($r = 0.06$, $P = 0.12$). There was a significant relationship between the proportion of antemortem lost teeth and periodontal disease ($r = 0.39$, $P < 0.001$), between periodontal disease and proportion of carious teeth ($r = 0.11$, $P = 0.007$), and between proportion of carious teeth and those antemortem lost teeth ($r = 0.12$, $P = 0.001$).

Using stepwise multivariate analysis, the proportion of teeth with periodontal disease was related with age at death (beta = 0.50, $P < 0.001$), proportion of teeth with calculus deposition (beta = 0.18, $P < 0.001$) and proportion of carious teeth (beta = 0.12, $P = 0.017$), in this order. A similar result was observed considering only the individuals buried in caves (age at death beta = 0.49, $P = 0.000$; proportion of teeth with calculus deposition, beta = 0.19, $P = 0.001$; proportion of teeth with carious lesions beta = 0.12, $P = 0.029$), but only age at death was independently related with proportion of alveoli with periodontal disease among those buried in tumuli ($b = 0.51$, $P < 0.0001$).

Table 5
Proportion of affected teeth (median and interquartile range) in individuals buried in caves or in tumuli

	Caves		Tumuli	
	Men	Women	Men	Women
Teeth with calculus	64.0 (40.0–87.5)	60.0 (33.3–85.0)	80.0 (50.0–93.8)	66.7 (50.0–84.5)
Periodontal disease	25.0 (0.0–50.0)	15.4 (0.0–40.0)	20.0 (0.0–42.9)	25.0 (0.0–50.0)
Antemortem teeth loss	6.3 (0.0–19.1)	12.5 (0.0–25.0)	9.4 (0.0–30.4)	0.0 (0.0–6.9)

Table 6
Proportion of individuals with affected teeth according to age at death (Median, interquartile range)

	Calculus	Peridontal disease	Antemortem teeth loss
17–24 years	57.1 (29.5–83.9)	0.0% (0.0–14.3)	0.0 (0.0–3.2)
25–35 years	76.9 (50.0–93.7)	28.6 (10.0–50.0)	6.3 (0.0–12.5)
35–45 years	66.7 (50.0–85.7)	33.3 (16.7–66.7)	12.5 (0.0–17.6)
45 + years	50.0 (0.0–80.0)	50.0 (21.3–89.6)	53.2 (32.8–71.4)

Age at death (beta = 0.42, $P < 0.001$); proportion of carious teeth (beta = 0.13, $P = 0.009$) and proportion of teeth with periodontal disease (beta = 0.15, $P = 0.011$) were related to antemortem teeth loss. Age at death (b = 0.38, $P < 0.001$), proportion of periodontal disease (b = 0.17, $P = 0.011$) and proportion of carious teeth (b = 0.14, $P = 0.015$) were related to antemortem tooth loss among those buried in caves, whereas only age at death was related with this parameter in those buried in tumuli (beta = 0.71, $P < 0.0001$).

The parameters ''buried in tumuli or in cave'' and ''antiquity'' did not enter the final formulas.

4. Discussion

Assessment of calculus deposition may provide useful information regarding dietary habits of ancient population groups, although the exact meaning of the development of calculus is not fully understood. Some authors defend that calculus deposition may be mainly related to consumption of protein-rich food, as fish or meat [14,15], whereas others have found that diets rich in carbohydrates may promote calculus deposition [16]. Several experimental data [33] and clinical observations [6] support the view that both the presence of urea -a product of aminoacids metabolism- and alkaline pH contribute to plaque mineralisation. The higher proportion of teeth with calculus among the inhabitants of the coastal areas, buried in tumuli, may indicate a greater consumption of proteins than the population buried in caves. Interestingly, carious lesions were less frequent among the people buried in tumuli [5]. Consumption of vegetables is generally associated with a high prevalence of caries [13] and an inverse relation between caries and calculus is expected to occur [8]. In our study we have failed to find any correlation between the proportions of teeth with carious lesions and with calculus deposition, but individuals with at least one carious lesion also showed at least one tooth with calculus deposition. This is not surprising, since calculus may harbor bacteria which may also lead to caries development. This may explain the significant association between calculus and carious lesions observed in this study.

We also found a significant correlation between the proportion of teeth with periodontal disease and the proportion of teeth with calculus. Some of the bacteria living in the plaque are related with the development of periodontal disease [26,34]. Actinobacillus actinomycetemcomitans is a well known pathogen capable of stimulate CD4 + T cells and induce the production of RANK-L, which activates osteoclasts, thus leading to alveolar destruction and tooth decay [26]. Thus, there is a pathogenetic pathway to explain our results regarding the association between periodontal disease and calculus deposition, an association which was found not only with respect to the prevalence of individuals with these lesions, but also regarding the proportions of teeth affected by both lesions.

Antemortem loss of teeth is a pathogenetically multifactorial event. Indeed, extensive, destructive carious lesions with pulpar exposure [17], tooth fracture, or super eruption to compensate for intense attrition [4], as well as periodontitis [16], traumatism, and ritual ablation, may all lead to antemortem teeth decay. So far we know, teeth extractions/ritual ablations were not performed in the prehispanic society of Gran Canaria, so caries and periodontal disease remain as the two main pathologies influencing on antemortem tooth loss in our series. Indeed, multivariate analysis shows a close relation between proportion of antemortem teeth loss and periodontal disease, caries, and, more closely, age at death. Therefore, age at death seems to be the most important factor determining tooth decay—in accordance with other authors [16,25], but it is important to point out that caries and periodontal disease are also factors which are independently related to teeth loss, but only in the population who buried in caves, not in that buried in tumuli, perhaps due to the higher prevalence of carious lesions among the former [5].

The finding of a higher proportion of teeth with calculus deposition among the people buried in tumuli (mostly located in coastal areas), lend further support to the hypothesis that these individuals consumed a different diet than those buried in the central highlands. As commented, two other kind of findings point in the same direction, i.e., the high prevalence of auricular exostoses among the population of the coast, and the higher bone Ba/Sr ratio shown by these individuals. These data also accord with some chroniclers writings in which fishing and shell fishing activities were widely performed by the islanders from Gran Canaria.

There are some gender differences in our study. Periodontal disease was more common in men, as well as the proportion of teeth affected by periodontal disease. Also, globally, the proportion of male teeth with calculus deposition was higher than the proportion of female teeth with calculus deposition. If we admit a relation between calculus deposition and a protein-rich diet, these findings may be interpreted as indicative of a lower consumption of protein by women. Interestingly, oral health status seemed to be better among women, especially among those buried in tumuli, who showed a lower proportion of antemortem teeth loss. All these findings may reflect different dietary patterns. However, differences are subtle. Indeed, sex did not enter any of the stepwise multivariate analyses, a result which indicates a lack of independent relationship between sex and periodontitis, calculus deposition, and tooth decay.

Thus, these data suggest that the population buried in caves had a different dietary pattern than that of those buried in tumuli. Taking together the higher proportion of teeth affected by calculus, and the lower prevalence of carious lesions, it is likely that consumption of fish and/or animal proteins was more important among the population buried in tumuli than among the individuals of the central highlands, who buried in caves and consumed plant products as their main food. Our study also point to subtle differences in diet between men and women, possibly these last consuming less protein than men.

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