Evaluation of dental non-metric traits in a medieval population from Ibiza (Spain)

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Abstract
Rescue excavations between 2006 and 2008 of the Medieval rural cemetery of Molí de Can Fonoll in Ibiza, Spain, revealed a total of 167 individuals, of which 141 were assessed for dental morphological variants. The analysis aimed primarily at assessing the frequency of dental non-metric traits in this population. 21 dental non-metric traits were selected for observation based on the Arizona State University Dental Anthropology System. No considerably high percentages were found in the population and no comparative data was present to infer about biological distances. Thus, the aim was to present the data for future study and to provide a small register for the region. The most significant frequencies of crown morphological variants found to be present within this Mediterranean population were hypoconulid (38.22%), shoveling (21.79%), and tuberculum dentale (19.18%).

Keywords: Dental Non-Metric Traits; Medieval Population; Spain

Introduction

This paper is based on an unpublished research dissertation which has focused on the study of human dental remains from the Islamic medieval cemetery of Can Fonoll in Ibiza, Spain (1). The island of Ibiza, is part of the Balearic Islands and is located in the Western Mediterranean, approximately 80 km off the eastern coast of the Iberian Peninsula. Due to its location, the island has been settled by many different populations including the Phoenicians, Carthaginians, Romans, Byzantines and Moors (2). Due to these different cultures and periods, it may be possible to hypothesize the arrival of immigrants from a number of geographical locations, and therefore to explore the degree of biological continuity. Especially significant is the connection of Ibiza not only with the Iberian Peninsula but also with North Africa and the Eastern and Central Mediterranean (e.g. see 2).

The objectives here are to present a summary of the data with regard to dental non-metric traits from the cemetery of Can Fonoll and to address in the best way possible the following questions:

- What are the frequencies of the morphological characters observed within the Molí de Can Fonoll assemblage?

- Are the trait frequencies observed consistent with the known geographic distribution of that trait?

The degree of fluctuating asymmetry will also be briefly stated. It is hoped that the data obtained can contribute to the non-metric trait record for the period and region, and this paper is therefore one step to achieving that.

Due to the lack of data from other periods and cemeteries for the island and the limited data available in the Balearic Islands and Spain, the paper can only limit itself to providing an opportunity to evaluate the dental non-metric traits of a 10th-13th century population systematically for the first time in Ibiza. The data also derives from the largest excavated cemetery in Ibiza dating from this period (3) and which has also been anthropologically studied (see 4). In addition, it adds to the limited data available for Spain for dental non-metric traits from archaeological populations. Non-metric dental variants are variants in the morphology of the crown or root that are considered minor anomalies which are thought to be influenced by hereditary factors (e.g. see 5). Studies of these variations have been used to understand genotypic differences within and between populations, making interpretations in relation to population affinity, microevolution, genetic drift, gene flow and natural selection (e.g. 5-9). With the debate of whether the traits are adaptive or non-adaptive, or that the survival of traits is based on chance or selection (e.g. see 10), there is an assumption that the heritability of these may provide good information in relation to reconstructing migration patterns in the past and also is significant in the understanding of human evolution. It has been used, therefore, to answer questions relation to patterns of human variation amongst different geographic regions, although there is still a need to further understand the nature of each trait (11, 12). In areas where there has been a change of cultural practices, for example, from one period to another, it has contributed to addressing the issue of whether there was a spread of ideas or colonization by immigrants; and addressing questions of biological continuity and biological distances (e.g. see 13-15). In cemeteries, the use of dental non-metric traits has been used to investigate any spatial patterning in relation to family clusters in cemeteries (e.g. see 16). Finally, in forensic investigations, suggestions have been made about their use to determine ancestry (e.g. 17) alongside other skeletal indicators.

Alongside these traits, fluctuating asymmetry (e.g. see 18) has also been investigated. The occurrence of fluctuating asymmetry in the dental arch (antimeric asymmetry) is considered by some to be directly proportionate to inherent extrinsic deviations of developmental and genetic stresses to the fetus during dental development (10, 18-24). However, some workers adhere to the notion that environmental factors, such as noise, cold and heat, challenge developmental stability and thus are related to antimeric asymmetry (8, 10).

In Spain studies on dental non-metric traits have been limited although some useful data has been published for archaeological and modern populations (e.g. 25, 26). However, the data is yet insufficient to enable comparisons between Ibiza and other locations in the Western Mediterranean, which limits any analysis of biological distance and excludes at present raising questions in relation to population movement. Nevertheless, it is hoped that the results obtained can add to that record and promote the use of dental non-metric traits for a better understanding of Ibiza's history. The materials employed in the present analysis and the methods used, followed by the results and a discussion of these are presented below.

Materials and methods

The human remains derive from 167 inhumation burials excavated during a rescue excavation at the site of Molí de Can Fonoll, located on the southwest of Ibiza, between October 2006 and February 2008 (Figure 1). From the 167 skeletons (71% were adults), only 141 preserved their dental remains. This rendered a total of 4,365 teeth of which only 2,855 could be assessed. The other teeth were deemed to be unobservable due to a number of factors including poor preservation, wear and caries which also raised the question of the reliability and comparability of the sample (6).

The burials date between the tenth and thirteenth century AD and the deceased had been buried in the Mediaeval Muslim ritual with no grave goods and resting on their right side and facing south/southeast towards Mecca. Skeletal preservation was poor with most of the cortical bone affected by considerable weathering and the enamel was also found to be affected and at times brittle (see 4), which very much limited the information that could be obtained.

Apart from variation in size, there are a number of dental variants which can relate to variation in the number of teeth, morphological variations affecting either crown, roots or the whole tooth (8). Commonly, there are two types of morphological variants that exist within the human dentition. The first group of variants can be deviations from the standard dental formula, such as twinning, hypodontia or hyperdontia (10, 27-29). The second group comprises minor deviations that affect crown and root morphology. Inconsistencies in the appearance of teeth such as ridges, depressions, fissure patterns, and cusp numbers (30, 31) are some of these minor variations, and the non-metric dental traits which are the matter of the present study.

A total of 141 individuals with permanent dentition were assessed for non-metric dental traits over a period of three weeks in May 2010 by one observer (CSP). The assessment of the dental sample from the Molí de Can Fonoll assemblage was undertaken by macroscopic observation and according to the Arizona State University Dental Anthropology System (ASU) following Turner et al. (1991). Only 21 were assessed (Table 1) in the population and their choice, definitions and the criteria employed can be found in a more detailed analysis by Pacelli (1).

Frequencies were obtained for the following dental non-metric traits (Table 1):

The classification criteria followed the standards mainly of Hrdlicka (30, 32), Robinson and Allin (33), van Beek (34), Buikstra and Ubelaker (35) and Scott and Turner II (10). No frequencies per individuals were reported in this study but only per number of teeth observed. Sexes were pooled since several studies have reported no sexual dimorphism (e.g. 36), including some analysis of traits in Spanish populations (26).

The raw database from the site containing non-metric variables, were placed into a Macintosh program called Numbers. The frequency of each trait, for each individual tooth, was scored by the following procedures: absent [0]; present [1]; unobservable score [9]. Data was imputed into SPSS 17 (Statistical Package for Social Sciences), in order to assess relationships within the dentition statistical analyses where appropriate (see 1).

Figure 1. Aerial view of the excavation in progress. Photo courtesy of Jonathan Castro and Joan Roig.

Traits observed	Teeth evaluated
Shoveling	UI1, UI2, LI1, LI2
Tuberculum Dentale	UI1, UI2, UC
Interruption Grooves	UI1, UI2
Lateral Incisor Variant: Peg-Shaped	UI2
Bushmen Canine	UC
Distal Accessory Ridge	UC, LC
Double Rooted Lower Canines	LC
Paracone/Protoconid	UP1, UP2, LP1, LP2
Accessory Marginal Tubercles	UP1, UP2
Root Number	UP1, UP2
Carabelli's Trait	UM1
Parastyle	UM1, UM2, UM3
Enamel Extension	UM1, UM2, UM3
One and Two Rooted Upper Molars	UM2
Hypoconulid	LM2
Dryopithecus Groove Pattern	LM2
Protostylid	LM1
Lower Molar Root Number	LM1, LM2
Three Rooted Lower Molars	LM1

Codes: U = Upper, L = Lower, I = Incisor, C = Canine, P = Premolar, M = Molar. E.g. UP2 = upper second premolar.

Table 1. Traits scored in the present study

Results

Table 2 and Figure 2 present the frequencies of the discrete characters present within the Islamic assemblage from Ibiza. A complete inventory of each trait, raw data illustrating frequency tables of each non-metric trait present on the associated tooth, detailed results on fluctuating asymmetry, inter-trait correlation, and crown height and trait differences can be found in the work of Pacelli (1).

Although unfortunately at present no data has been obtained per individuals affected nor have all the frequencies been compared, the following traits displayed the highest frequency (>10%) within the population: hypoconulid (38.22%), root variation of upper first premolar (37.43%), shoveling (21.79%), root variation on upper molars (19.18%), root variation on upper second premolar (15.24%), tuberculum dentale (13.35%) and dryopithecus groove pattern (12.26%). Due to the rarity of some traits, it is worth noting their presence, for example the frequencies of peg-shaped teeth (3.17%), Bushmen canines (2.27%) and double-rooted lower canines (3.95%). Other values between these higher and lower figures and are also worth considering. Figure 2 displays the frequencies of non-metric traits in the population.

Trait	Number of teeth observed	Total number of teeth with traits present	Frequency (%)
Shoveling	1005	219	21.79
Tuberculum Dentale	322	40	13.35
Interruption Groove	317	15	4.73
Peg Shape	189	6	3.17
Bushman Canine	176	4	2.27
Paracone Ridge	386	2	0.52
Root Variation UP1	171	64	37.43
Root Variation UP2	164	25	15.24
Hypocone	214	6	2.8
Carabelli's trait	434	21	4.61
Parastyle	526	1	0.19
Enamel Extension	757	44	6.08
Root Variation UM	146	39	19.18
Double Rooted Lower Canine	152	6	3.95
Protoconid	386	5	1.28
Dryopithecus groove pattern	155	19	12.26
Hypoconulid	15	60	38.22
Protostylid	208	3	1.44
Root Variation LM1	108	2	3.7

Table 2. Trait frequencies within the Molí de Can Fonoll Medieval population

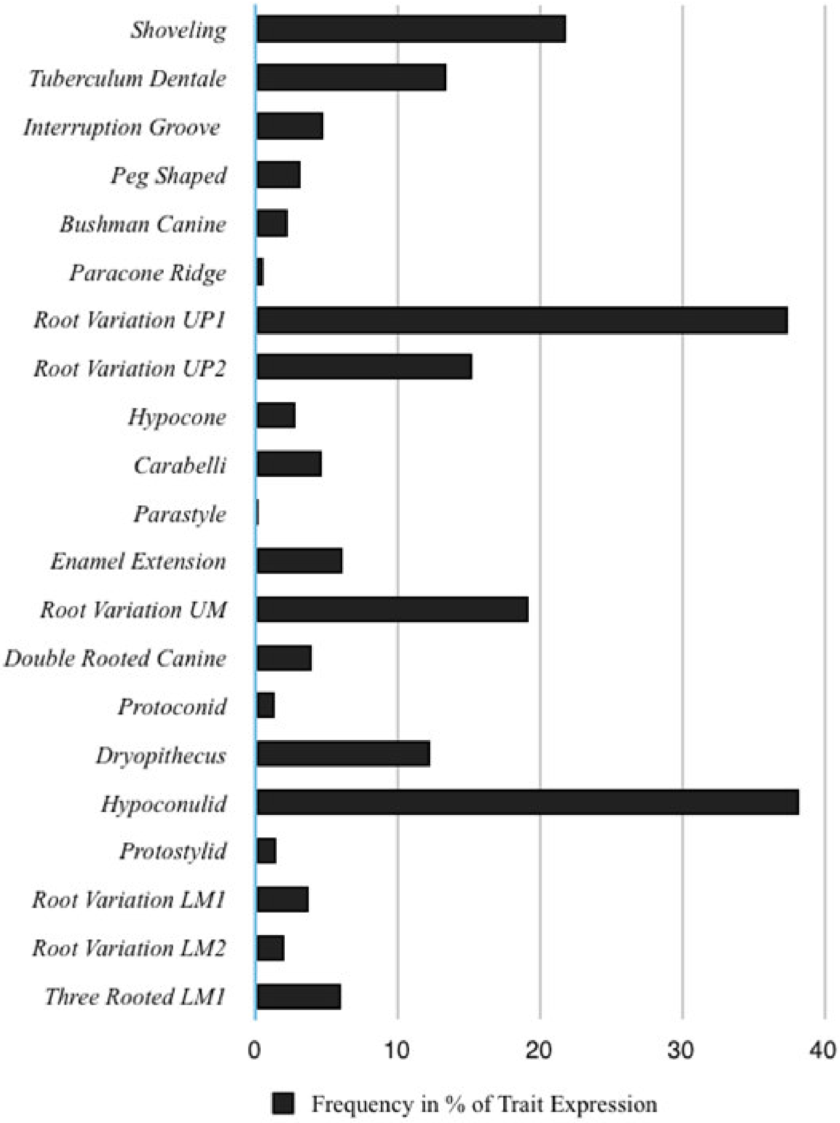

Figure 1. Non-metric trait frequencies present in the Molí de Can Fonoll assemblage.

Discussion

The alteration of tooth morphological features does not change across a span of time without cause; as such, tooth morphology is a biological affinity that remains with an individual as they migrate to different locations (10). It has been suggested that some dental variants are constant within a given geographical area or “isoincidence lines,” which suggests that the frequency of the trait can be mapped within a population (37). Although there might be the assumption that genetic variation acts on each non-metric trait equally across populations which has not been recognized explicitly, the frequency of the 21 traits found within the Molí de Can Fonoll assemblage may still be compared to established global frequencies, and inferences may be made regarding possible migration.

Nevertheless, spatially and temporally close comparative dental anthropological research is limited due to the lack of osteoarchaeological data on dental non-metric traits from the Balearic Islands.

The questions addressed in this paper are the frequencies of dental variants in the population and a comparison of the global frequencies in order to contribute to our understanding of the Medieval Islamic period in Ibiza. As observed earlier (Figure 1), the most significant frequencies of crown morphological variants found to be present were hypoconulid, shoveling, and tuberculum dentale. With regards to root morphological variants the most prevalent traits were root variation on the first upper premolar, on the upper first molar and on the upper second premolar. Of course, it must be borne in mind that low frequencies can be as significant as high frequencies too.

Although a major contribution to the period would be to contextualizing the data by comparing it to samples from different periods from Ibiza, a number of observations can be made on a preliminary basis. Scott and Turner II (10) identified the geographic distribution of some non-metric variables from data summarized by workers in the field, and from their own extensive compilation of data. The data was based the analysis of over 25,000 skeletal remains from a number of geographic distributions and from the last 10,000 years. Five subdivisions or classifications were used here to demonstrate the geographic distribution of traits, although they do not reflect recent colonization or population movements: 1) Western Eurasia, 2) Sub-Saharan Africa, 3) Sino-Americas, 4) Sunda-Pacific, and 5) Sahul-Pacific (10).

The trait with the highest frequency in the Ibizan sample was the reduction of the hypoconulid cusp (38.22%). In most human populations, hypoconulid reduction is rare. In fact, the presence of five cusps on the lower first molar occurs in all human populations with frequencies of 85-100% (10). With regards to the geographic distribution of hypoconulid reduction, it is found in frequencies between 30% and 60% in South Africa, North and East Asia. The highest frequencies (although <60%) are found in Western Eurasia, with the lowest frequencies (<10%) in Siberians, Native Americans, and Australian Aborigines.

Shoveling of the incisors and canines (21.7% in the Ibizan sample) is a polygenic trait that varies in expression between human groups, and according to Hrdlicka (38) appears to be relatively stable within groups. Shoveling is most prevalent in Asian and American groups (60-90%) with the lowest frequencies (0-15%) found in Western Eurasian, Sub-Saharan African, and Sahul Pacific groups. It should be noted that other researchers have found shoveling to be present at a rate of 20-25% in admixture populations including those from Yemen, Sudan and Egypt (39), which may be of interest in relation to Ibiza. The geographic distribution of shoveling, however, cannot be compared due to differences in scoring.

Root number for the first upper premolar in Homo sapiens has provided ambiguous interpretations. Some studies have presented data that indicates up to 90% of samples are single-rooted; however other researchers have reported two-rooted samples with frequencies above 83% (40). The frequency of two-rooted upper first premolars was found to be 57.47% within the Molí de Can Fonoll assemblage. Frequencies of 30% and 60% have been found in the following areas: Western Eurasia, Sunda-Pacific, and Sahul-Pacific. More specifically, Scott and Turner II (1997: 225) reported the findings of worker Greene (41) who found frequencies around 62% in North African populations.

Little is known regarding the geographic distribution of tuberculum dentale. The character was expressed on 13.35% of the total sample from Ibiza. A study from Portugal (42) indicates sexual dimorphism on a 19th century population with a high frequency of over 70% on incisors and 60% on canines. Moreno (43) also has incidence of over 70% on incisors and canines on a sample from the Iberian Peninsula.

The Bushman canine, considered to be a rare trait has distinctive patterns of distribution. Within the Molí de Can Fonoll assemblage, the trait was observed on one individual with symmetrical expression resulting in a frequency of 2.27%. The highest frequency (12-35%) has been found in Sub-Saharan groups (10) and the lowest (0-3%) in Sino-Americans, Sahul-Pacific and Polynesians.

It is extremely rare to find double rooted lower canines in human groups; however, when they do appear, it is rare to find them outside of Europe (10). The findings reveal that out of 74 observed lower right canines, three (4.1%) were double rooted. Similarly, out of 78 observed lower left canines, three (3.8%) had the variant. The total frequency for this trait of all lower canines was 3.95%. Global frequencies between 2-4% are characteristic of North African and South Siberian groups.

Little is understood regarding the significance and geographic distribution of maxillary lateral incisor variants, but they are typically considered extremely rare in populations with recorded frequencies of 0-3%. Of 189 lateral incisors observed in the Ibizan sample, 6 (3.17%) had variation.

The frequency of the dryopithecus groove pattern in the Molí de Can Fonoll assemblage was found to be 12.26%. The lowest frequency (10-20%) has been reported for North and East Asians, Native Americans, Sunda-Pacific groups, and Australian Aborigines (10).

It is felt that interpretations are restricted with these results. On the one hand, the data has been presented but would require biological distance analysis with a number of populations from the Balearic Islands, Iberian Peninsula, North Africa and Sub-Saharan Africa for the same traits. Frequencies should also be within different periods in Ibiza to explore the degree of biological continuity through time, including the present day population. In addition, every single trait should be explored but also all traits should be explored together and in relation to frequencies of individuals affected. This has also got to be borne in mind in that some expressed traits may correlate with the presence or absence of other variants. Additionally, some traits may need to be prioritized before others and also interpreted with other anthropological data (e.g. cranial morphology) and within a wider biocultural understanding of that period.

With this regard it is believed that the current research cannot at present provide any significant contribution to understanding the Medieval Moorish past of Ibiza. We can certainly indicate that there are no high frequencies for presence of a trait that stand out; and that the low frequencies do not provide any support at present for a clear group of immigrants from a particular location. It would be of risk to attempt to further our interpretation.

What this data may provide at present are the potential reflection of living conditions through fluctuating asymmetry (e.g. see 18). This of course may be corroborated with other pathological data and paleodietary analysis (studies ongoing). Regarding fluctuating asymmetry present within the sample, the study by Pacelli (1) illustrates that tuberculum dentale has the highest frequency of fluctuating asymmetry between the antimeres of the upper canines (11.7%) and lateral incisors (11.3%), whilst shoveling, Bushmen canine, and double-rooted canine are all expressed symmetrically in the maxilla. However, both the mandibular central and lateral incisors show asymmetry frequencies of 5.6% and 4.4% respectively. In premolars and molars, enamel extension has been found to have the highest rate of fluctuating asymmetry (15.3%) when expressed on the lower first molar antimeres. A number of other traits on the premolars and molars have produced fluctuating asymmetries around 10% (hypoconulid, Carabelli's cusp). The asymmetric expression of morphological variants within the Molí de Can Fonoll dentition could be due to inherent and/or extrinsic factors, such as genetic abnormalities, developmental stress, malnutrition and disease. However isolating the exact biological or environmental factor with regard to asymmetry as well as its degree of influence is not possible to determine.

Conclusion

The aim of this research was to analyze dental morphological crown and root variants expressed on human dental remains excavated from the Molí de Can Fonoll cemetery in Ibiza, Spain, and to understand something about the population where possible. The assemblage provides a good sample from the Medieval Moorish period in Spain. The analysis of non-metric dental traits included assessing the frequency and interpreting within the geographic distribution of frequencies for a particular trait. Analysis of the dental inventory revealed that only 66.82% of the teeth were available for assessment. The remaining 33.18% were missing, of which 32.5% were related to ante-mortem loss. Out of 21 traits assessed variants, with varying degrees of frequency, were found to be present within this population.

It is understood that the alteration of tooth morphological features does not change across a span of time without cause; as such tooth morphology has a biological affinity that remains with an individual as they migrate to different locations. Results from this analysis, whilst cannot provide specific migratory patterns of past peoples, does indicate that certain traits have similar frequencies as those found in Western Eurasian groups, and this would include North Africa. If anything, it may reveal frequencies of these traits that may be of sue for future studies seeking dental non-metric comparative frequencies of this area of the Mediterranean.

In spite of the small sample size, this research may be of importance to promote further dental non-metric trait studies for anthropologists working especially in Ibiza and also will be contributing to the dental non-metric trait register for the area. Further research on other aspects including demography, cranial morphology, DNA, disease and stable isotope analysis, for example, will need to be combined with this data and also historical information regarding migration patterns at different times.

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