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THE IMPORTANCE OF BILATERAL ASYMMETRY ANALYSIS ON HUMAN ARCHAEOLOGICAL PRE-CONQUEST POPULATIONS (THE CASE OF SIX COLOMBIAN PRE-CONQUEST POPULATIONS)

ABSTRACT: Bilateral asymmetry has been an important field of study in anthropology. The evaluation of bilateral asymmetry of four traits (one by type of upper teeth) is carried out in this study on six pre-Conquest human populations from Colombia (South America). Results show the importance of a previous analysis of bilateral asymmetry in archaeological fragmented samples and its relevance in posterior interpretations.

KEYWORDS: Bilateral asymmetry – Upper permanent dentition – Dental morphology – Shovel shape – Distal accessory ridge – Marginal ridge – Carabelli's trait – Colombia

INTRODUCTION

Symmetry is the antimeric repetition of a structure. In a morphological sense it can be defined as the structure divided by a point in two or more identical parts in size and shape, and in position relative to the dividing point; in other words, the repetition of exactly similar parts facing each other or a centre.

Van Valen (1962) grouped deviations from perfect symmetry in an organism into three categories: (1) directional asymmetry (form of the mammalian heart); (2) antisymmetry (right- and left-handedness); and (3) fluctuating asymmetry (an asymmetry involving a paired structure that is usually symmetrical). Fluctuating, mirror or flip symmetry may be either qualitative or quantitative. Bilateral asymmetry in tooth cusp occurrence (the presence or absence of a cusp on a tooth) is a qualitative fluctuating asymmetry (Staley, Green 1971).

Theoretically, antimeric teeth should exhibit symmetrical mirror imaging in respect to both size and surface detail (Scott 1977). Some studies suggest mirror imaging deviations in twins as result of the change effect of minor developmental disturbances of bilateral structures (Wetherell *et al.* 1994). Directional increase asymmetry has been found in occlusal morphology of first permanent molars from 45,X/46,XX mosaics, indicating that different cell lines regulated by different discrete genes can be responsible for the more pronounced differences observed on left than right molars (Piriniemi *et al.* 1998).

Observation of bilateral asymmetry expression in human dental morphologic traits has been used in anthropology as a measure of population heritability (Garn *et al.* 1966a, Staley, Green 1971, Baume, Crawford 1979). Little metrical differences between antimeric teeth have been reported previously (Garn *et al.* 1966b, Garn, Bailey 1977). Bailit *et al.* (1970) report the observation of different metric fluctuating dental asymmetry values in human populations. In a study about the invariable bilateralism presented by Carabelli's trait, Meredith and Hixon (1954) find that nearly 13% of the sample show expression of the trait only in one side of the dental arch, concluding a low variability in bilateral expression of this trait. Small differences were demonstrated by Wood and Green (1969) comparing the bilateralism of seven morphologic traits in premolars of

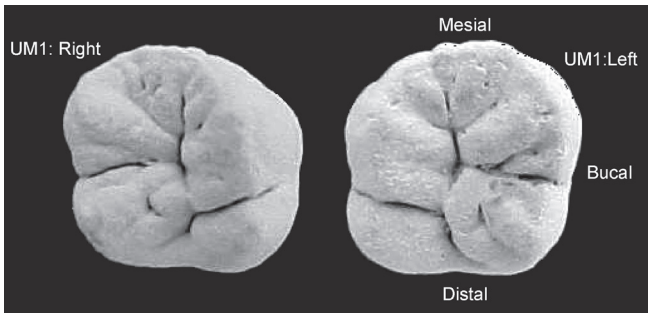

FIGURE 1. UM1 of Indiviual 7 from La Escopeta.

twins. A similar deduction in Carabelli's trait was found by Scott (1972, cited in Scott 1977) and Biggerstaff (1973).

An additional factor that can be important in the relevance of a bilateral asymmetry is the magnitude of the sample. Garn *et al.* (1979) report how the effect of small samples (generally below 100 and in some cases as small as 15), increase apparent intergroup differences in crown asymmetry and may reflect sampling limitations.

DENTAL ASYMMETRY IN ARCHAEOLOGICAL FRAGMENTED SAMPLES

The use of morphological variation from human dentition manifests some problems of methodological validity for archaeological fragmented samples. One of them is the assumption of dental trait expression as individually immutable, in the sense of invariability in both left and right sides of the dental arch.

In bio-archaeology, the presence of a dental trait is determined by the availability of the samples, slight crown wear (unexposed dentine), and absence of caries. Some authors recommend the record of highest expression grade for each dental trait (Turner, Scott 1977), or score the left or right side for each individual (Haeussler *et al.* 1988). These counting methods are very useful in the event that the bio-archaeologist has only fragmented samples (pieces from maxillas and mandibles).

Many researchers agree that these counting methods equal the taxonomic value of the dental traits, without taking into account the unilateral or bilateral expression. But, if this affirmation is considered faithfully, an anthropological study on archaeological samples could be carried out without a previous evaluation of bilateral asymmetry, thus under-estimating possible environmental influences on trait expressions as much as over-estimating its taxonomic value and relevance in phyletic and historical inferences. At this point, researchers are involved into a problem with only two possible alternatives: counting the trait as bilateral or discard the individual, consequently reducing the total sample size.

The bio-archaeological studies that use analyses of bilateral asymmetry previous to biological distances calculation are non-frequent.

While it may be true that bilateral asymmetry could reflect environmental influences, and its presence in the traits expression could induce their selection as a reliable trait in determining biological distances, we propose a study of bilateral asymmetry on dental types.

Before using the fragmented arch in a traditional counting of trait presence (Turner, Scott 1977, Haeussler *et al.* 1988), the bilateral analyses on available complete dental arches in the same population can add elements to discriminate useful comparative indicators in the crowns. The study is carried out in six human pre-Conquest populations from Colombia, with the aim of exploring the morphologic reliability of each dental type examined in these samples.

MATERIALS

This study includes data from six pre-Conquest human populations from Colombia dated between the 8th and 15th centuries AD (*Table 1, Figure 1*). The samples from cemeteries of Obando, Guacanda, and La Escopeta were excavated by Research Group ARQUEODIVERSIDAD between 1996 and 2001 in the south-west. Sample of Morro-Tambo is kept at the Museo de Historia Natural (Popayán), and Marin and Soacha samples are preserved at the Museo Nacional de Colombia (Bogotá).

Cultural traditions like Quimbaya Tardio, Sonso, Bolo-Quebradaseca, and Muisca associated with the dental samples belong to chiefdoms dated into later pre-Conquest period. This cultural period is characterized by a complex cultural organization based on strong hierarchical structures, intensive farming, more frequent economical exchange processes, and more elaborated social relationships between different populations geographically closed.

Samples were selected as follows: (1) dental samples associated with previously determined cultural traditions; (2) individuals between 10 and 20 years of age; (3) teeth with unworn occlusal surfaces (unexposed dentine) and absence of caries; (4) dental types present in both left and right sides of the maxilla.

The *n* value corresponds to the total number of individuals with complete arches examined.

METHODS

Permanent teeth of 58 individuals between 10 and 20 years of age with complete arches (maxilla) were selected. The dental traits used here are listed in *Table 2*. The ASU Dental Anthropology System (Buikstra, Ubelaker 1994) was used to register the expression grade of shovel shape UI1, distal accessory ridge UC, and Carabelli UM1. The marginal ridges UP were observed following the descriptions of Burnett (1996). Binary record system was employed, grouping all grade expressions into both "presence" (1) and "absence" (0) categories. With this record, the Molto's

TABLE 1. Materials used in this study.

Population	Centuries	Collection	Provenance	n
Obando	VIII–XIII	Museo Arqueológico, Univalle	Valle del Cauca	13
Guacanda	X–XV	Museo Arqueológico, Univalle	Valle del Cauca	9
La Escopeta	XIII–XV	Museo Arqueológico, Univalle	Valle del Cauca	6
El Morro–Tambo	XIII–XV	Museo de Historia Natural, Unicauca	Cauca	7
Marín	XIII–XV	Museo Nacional de Colombia	Cundinamarca	11
Soacha	X–XIII	Museo Nacional de Colombia	Cundinamarca	12
Total				58

TABLE 2. Observational methodology used in this study.

Dental type	Trait	Dichotomy	Presence	Absence
UI1	Shovel shape	0–6	1–6	0
UC	Distal accessory ridge	0–5	1–5	0
UP1	Marginal ridges	0–1	1	0
UM1	Carabelli	0–6	1–6	0

TABLE 3. Values observed in this study.

Population	Shovel shape UI1						Distal accessory ridge UC						Marginal ridges UP1						Carabelli UM1					
	BP			UP			BP			UP			BP			UP			BP			UP		
	n	k	%	k	%	BI	n	k	%	k	%	BI	n	k	%	k	%	BI	n	k	%	k	%	BI
Obando	13	10	76.92	1	7.692	90.91	13	10	76.92	1	7.692	90.91	13	8	61.54	2	15.38	80	13	5	38.46	2	15.38	71.43
Guaranda	9	7	77.78	2	22.22	77.78	9	5	55.56	2	22.22	71.43	9	4	44.44	3	33.33	57.14	9	2	22.22	2	22.22	50
La Escopeta	6	6	100	0	0	100	6	5	83.33	1	16.67	83.33	6	6	100	0	0	100	6	1	16.67	4	66.67	20
El Morro–Tambo	7	4	57.14	2	28.57	66.67	7	5	71.43	1	14.29	83.33	7	4	57.14	1	14.29	80	7	3	42.86	1	14.29	75
Marín	10	8	80	2	20	80	10	9	90	1	10	90	10	6	60	2	20	75	10	4	40	1	10	80
Soacha	12	9	75	3	25	75	12	10	83.33	1	8.33	90.91	12	9	75	1	8.33	90	12	3	25	2	16.67	60
∑	57	44		10			57	44		7			57	37		9			57	18		12		
Mean						81.73						84.99						80.36						59.4

*BP = Bilateral presence, UP = Unilateral presence, BI = Bilateral index, k = individuals with trait presence, n = total number of individuals.

TABLE 4. BI statistics calculated for each dental trait.

Population	Shovel shape UI1	Distal accessory ridge UC	Marginal ridges UP1	Carabelli UM1
mean	81.73	84.99	80.36	59.4
sd	11.91	7.544	14.47	22.15
cv (%)	14.57	8.877	18.01	37.29

*SD = Standard deviation, CV = Coefficient of variance

TABLE 5. BI statistics calculated for each pre-Conquest population, all traits considered.

	Obando	Guaranda	La Escopeta	El Morro–Tambo	Marín	Soacha
mean	83.31	64.09	75.83	76.25	81.25	78.98
sd	9.445	12.75	38.04	7.249	6.292	14.6
cv (%)	11.34	19.9	50.17	9.507	7.743	18.49

(Tocheri 2002) Bilateral Index (BI) was calculated using the coefficient:

$$BI=bp/(bp+up)\times100$$

Where: *BI* is the bilateral index value; *bp* is the bilateral occurrence of the trait, and *up* is the unilateral occurrence. The bilateral index reveals the symmetrical tendencies of a trait when it is present. According to Tocheri (2002), an index higher than 50 reveals a positive bilateral tendency of the trait. Standard deviation (*sd*) and coefficient of variation (*cv*) were also calculated for observation of intra and inter-population variation of bilateral traits presence.

RESULTS

Bilateral and unilateral presence of traits and bilateral index values are shown in *Table 3*. Bilateral expressions of shovel shape UI1, distal accessory ridge UC, and marginal ridges UP1 show a clear tendency to bilaterality with values higher than 50, with relatively low *sd* and *cv*. On the other hand, Carabelli's trait showed the highest *sd* and *cv* (*Table 4*). Comparing populations, exceptional values were found in La Escopeta which exhibit *cv* higher than 50% (*Table 5*).

DISCUSSION

In polygenetic inheritance, the interactions of a number of genes at different *loci* that may interact with environmental factors determine phenotypic variation of the trait. Various genes have different contributions to phenotypic variation and an additive effect on some trait (Lauc *et al.* 2003). Dental asymmetry has generally been thought to be an indicator of developmental stability in the humans. Recognition of bilateral asymmetry can be interpreted as a reflection of instability in normal development of biological forms (Palmer, Strobeck 2003). Results of this study suggest that the expression of the dental trait Carabelli in UM1 can be most easily influenced by environmental forces. Carabelli values <50 for Guacanda, and La Escopeta pre-Conquest populations show the relative low taxonomic reliability of this trait for future biological comparisons that include these two samples. *Cv* values for this trait (37.3%) and its variation in La Escopeta population (50.1%) support the assumption mentioned above. This dental trait could indicate more sensibility to environmental forces, and be considered as a possible indicator of small changes in the genetic pool of this prehistoric population. Other values greater but near to BI=50 were found in populations like Morro–Tambo (shovel shape UI1 BI=66), Soacha (Carabelli UM1 BI=60), and Guacanda (marginal ridges UP1 BI=57). The bilateral expression of these traits could also represent a relative environmental impact that would influence the phenetic component in the total sample. Distal accessory ridge displayed the highest values and reliability for its use in biological inter-group comparisons.

The recognition of bilateral expression of some dental traits like Carabelli, shovel shape, and marginal ridges is necessary in order to conclude the importance of previous bilateral asymmetry analyses in any dental prehistoric series. Estimation of bilateral index is important for the observation of possible environmental influences that can affect the total value of the trait expression as much as enough to exclude Carabelli's trait in posterior biological distances that polled all populations here considered.

CONCLUSION

The results of this research state that the population analysis of samples should be more cautious in the prior validation of some dental traits expressed in UM1, in this case Carabelli. To conclude, it is advisable to consider a previous bilateral analysis in archaeological fragmented samples, because it gives us additional control elements in an inter-sample interpretation.

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