DENTAL MORPHOLOGY IN THE ESTIMATION OF BIOLOGICAL DISTANCE: THE GRAY SITE

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A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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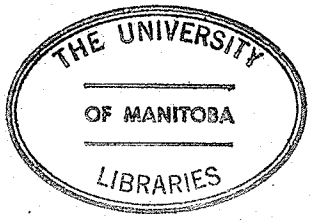

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Chapter 1

INTRODUCTION

The use of non-metric, osteological traits as indicators of biological distance has become popular in recent years. Among the research (see Kellock and Parsons,'70:409), studies on mice have been particularly informative. These have resulted in the development of statistical methods appropriate to non-metric, osteological analyses and have contributed to an understanding of the patterns of inheritance for non-metric variables.

Berry ('68) has used non-metric, cranial variation to estimate genetic distances between mouse populations. Gruneberg ('52) defined the quasi-continuous variable and its correlation with penetrance and expressivity in studies of skeletal variation of the mouse. This definition established two main characteristics of the quasi-continuous variable:

a) its underlying polygenic continuous nature, and

b) its discontinuous manifestation as a result of developmental processes. Modification of the continuous and additive character of the genotype in phenotypic expression has also been examined in plants (Weber,'59). The term "epigenetic" has been used by Berry and Berry ('67:362) to

indicate non-metric, osteological traits of multi-factorial determination.

In human populations, non-metric variation appears to exhibit similar morphological characteristics to mice. Berry ('68) has suggested that the morphological similarities imply similar modes of inheritance. Non-metric data have been applied to estimation of biological distance between native populations of India (Sanghvi,'53). This study demonstrated that estimates based upon morphological characteristics discriminated between populations complementary to estimates based upon blood groups, taste and color vision. Laughlin ('63) and Laughlin and Jorgensen ('56) have presented estimates of genetic distance based on cranial characteristics in Aleut and Greenland Eskimo populations, respectively. Berry and Berry ('67) have considered cranial non-metric variation in world poulations. Kellock and Parsons ('70) have analyzed patterns of non-metric cranial variation in aborigines and have gained insights into possible migrations in prehistoric Australia. Berry and Smith ('68) indicate that statistical analysis of non-metric variation may provide reliable estimates of genetic separation of populations than analyses based upon metric traits.

Studies of tocth morphology in the mouse suggest that dental traits are quasi-continuous variables under

pleiotropic genetic control (Gruneberg,'65). Sofaer ('69) demonstrated polygenic inheritance of a supernumerary molar cusp in the mouse, as opposed to a monogenic mode. Gruneberg ('52) showed variable penetrance and expression in third molar agenesis, associated with more than two stable levels of the character, a indication of quasi-continuous variability. Recently, Sofaer et al.('72b) have differentiated between native populations of the Southwestern U.S. and world populations. Their conclusions suggest that comparative studies in dental morphology, although suffering from a lack of standards for trait expression, may provide useful information about relationships between populations.

Objectives

The objectives of this study are 1) to describe and present frequencies of non-metric dental characters of the Gray site population and 2) to interpret the biological relationship of the Gray site to selected Asian, Eskimoan and Amerind populations. The common rationale for the use of the dentition in the study of skeletal remains includes the post-mortem preservative qualities of the teeth, the reduced environmental effect on developing elements due to the complete development before eruption (Dahlberg,'62) and high genetic component (Greene,'67a; Turner,'67b;'69).

The second objective, the use of dental characters in the estimation of biological affinity of the Gray site to other Mongoloid populations, is an independent discriminator of North American aboriginal relationships. The Gray site represents occupants of a geographical region previously undefined as to physical type. An analysis of biological distance presents evidence and permits discussion of prehistoric interpopulational relationships and/or migrational influxes into the New World.

Approach

The Gray site population is evaluated with respect to most dental traits commonly studied in the field (see Dahlberg,'51;'63) and other characters that have been referred to as "anomalies" of the dentition (Appendix:135). Frequencies of trait manifestation are based on numbers of teeth thus, no consideration is made for individual bilateral asymmetry. This decision is prompted by the incomplete nature of the skeletal material.

Although there is some indication by radiocarbon dating that the entire sample may represent more than one population, So and Wade ('75:2) believe that "(T)he use of the site may have been less discontinuous than would seem initially apparent on the basis of the relatively small number of dates." In the absence of any sound basis for possible division of the site temporally the material is assumed to represent a genetically homogeneous population over an extended period of time.

The statistical analysis in the third chapter is employed under the premise of the existence of quasi-continuous variation in dental traits. This assumes that the underlying range of continuous variation is related to the development of the character. The relationship between incidence and degree of expressivity of the

quasi-continuous variable is such that "...as the continuous distribution crosses the critical level, the first few normals will generally be only slightly affected; as the distribution is further shifted in the same direction, an increase in the percentage of abnormals will go together with the appearance of more severely affected individuals (Gruneberg,'52:108)." The critical characteristic of any variable is the position of its mean, as the mean is an approximation of the threshold position and this can be estimated from population frequencies of the affected class. Sofaer et al.('72b) indicate that further classification gives no information except for a test of equality of variance between populations (this is assumed to be equal). Therefore, all observations were distributed between two classes, "affected" or "non-affected", from which were calculated Chi-square estimates of divergence (Sanghvi,'53:393; Sofaer et al.,'72b:359). Chi square = sum (1...n)*sum (1...r)* ((P1-Q)*2/Q + (P2-Q)*2/Q)/ degrees of freedom, where:

P1 and P2 are percentage incidences of two populations of each of r classes in which a given character is scored.

Q = (P1+P2)/2

n = number of characters scored

Degrees of freedom = n(r-1)=n, as r=2 in every case.

A discussion and interpretation of results follows.

Chapter 2

THE MORPHOLOGY OF THE GRAY SITE

Material

The present study is based upon examination of the skeletal remains of the Gray site, near the town of Swift Current in southwestern Saskatchewan and radiocarbon dated at 5100-3485 B.P. (So and Wade,'75). A detailed account of the site is to be found in Millar et al.('72). A summary of possible cultural affinities is presented in Knutson ('75).

A total of 141 (complete and fragmentary) individuals were examined ranging in age from 4 years to adult. The individuals are represented by 100 maxillae and 116 mandibles.

Individual tooth counts reveal a high rate of post-mortem loss. In the incisor region, an average of 50% of the teeth are missing while molars are lost postmortem in direct proportion to the tendency of their roots to fuse (average postmortem loss of all molars, mandibular and maxillary, is 25%). The degree of attrition is generally pronounced.

X-rays aided in the determination of hypodontia, impaction, hyperodontia and root fusion.

Incisor Shovelling

Table 1 presents frequencies of the shovel character in incisors of the Gray site. Dahlberg ('51) has suggested that the use of pronounced and moderate forms is a more reliable method of comparing findings of different authors. Thus, the subjective scale of incisor shovelling of Hrdlicka ('20) was slightly modified as follows:

Hrdlicka's scale	Present study
- shovel	- pronounced
- semi-shovel	- moderate
- trace shovel, no shovelling	- absent

The metric technique of recording shovelling suggested by Dahlberg and Mikkelson ('47) and used by Goaz and Miller ('68) and Rothhammer et al.,('68), was not applied to the present data due to the prevalence of extreme attrition in the Gray site remains. Where wear is not below the enamel rim that defines the shovel character, the cross-sectional incisor shape is used to determine degree of shovelling.

Frequencies of shovelling in the Gray site material with respect to sex were not considered due to the greater number of individuals of indeterminable sex. Sexual differences in shovelling are not believed to be statistically significant (Greene,'67a). Rothhammer et al., ('68) found women with higher indexes of shovelling in a

Chilean population but stated that the result may be accounted for by sampling error.

The Gray site exhibits the typically Amerindian frequency of maxillary incisor shovelling, characterized by a high percentage of observations in the pronounced and moderate categories of trait expression (Dahlberg,'63). This contrasts with Caucasians, who show a predominance of trace and moderate degrees, and Negroid populations who exhibit a frequent absence of shovelling (Carbonell,'63). Differences of shovelling among Oceanic populations suggest a dispersion of pro-Mongoloid groups from Indonesia to Polynesia (Riesenfeld,'56; Suzuki and Sakai,'64).

In mandibular incisors, the shovelling trait is not as pronounced or as frequent as among maxillary incisors, an observation also noted by Turner ('67b). Among Peruvian Indians, Goaz and Miller ('68) found mandibular incisors with less pronounced shovel forms than their maxillary counterparts, although both were characterized by 100% shovelling.

Table 1

Incisor Palatal Shovelling in the Gray Site

	Maxilla		Mandible	
	I1	I2	I1	I2
Pron.	85.7	77.3	0.0	0.0
Mod.	11.9	18.2	61.1	46.1
Pron. & Mod.	97.6	95.5	61.1	46.1
Trace & Abs.	2.4	4.5	38.9	53.9
N	42	44	36	39

Missing and Anomalous Lateral Incisors

The study of Bradlaw ('34) of a three generation pedigree established a genetic connection between the inheritance of dwarfed and absent maxillary lateral incisors. Later studies have shown that agenesis and peg-shaped maxillary lateral incisors are variations of the same genetic complex (e.g., Taylor,'69). In a study based on admixed Hawaiian schoolchildren, Chung et al.('72) conclude that peg laterals and missing laterals are variations of a trait of multifactorial inheritance. The frequency of the complex may be much higher than reported in earlier studies.

Whether peg-shaped and anomalous lateral incisors are variations of the same complex is open to question. Dahlberg ('51) includes malformations of the cingulum, principally the barrel shape and dens en dente, as manifestations of the anomalous form. In the present study all cases of reduced incisors were regarded as manifestations of the same genetic trait, although in instances of severely worn teeth it was often not possible to determine if the barrel shape had ever been present. Presumably, all forms are related to the reduced maxillary lateral incisor as this is the sole site of their occurrence (Dahlberg,'51).

The frequency of missing upper laterals (excluding peg laterals) is in the vicinity of 2.5% in world populations. No clear pattern of variability is evident from the

frequencies available for human populations, "...there being relatively low and high figures among the European, Mongoloid, and Negroid samples studied" (Brothwell et al.,'63:182). Frequencies of missing and anomalous lateral incisors in American Indian populations have been reported by Dahlberg ('51).

The Gray site population is seen to be within expected Mongoloid frequencies for congenital absence of upper laterals whereas the frequency of the anomalous forms is higher (Table 2). Different forms of the reduced incisor have probably not been considered as manifestations of the missing incisor complex and this may in large part explain the differences from frequencies reported by previous investigators. On the other hand, the presence of relatively high incidences of the reduced incisor form are found in Indian Knoll, Navaho and South American Indian dentitions (Dahlberg,'51; Dunkel,'65; Niswander,'67 and Goaz and Miller,'68, respectively).

The sex distribution of missing and anomalous laterals in the Gray site is presented in Table 3. Previous reports have indicated a tendency for anomalous forms to be more common in males and agenesis higher in females (Hrdlicka,'21; Schultz '32;'34; Montagu,'40). However, there are exceptions (Chung et al.,'72; Beiquelman,'62).

The barrel shaped lateral incisor is considered a

Mongoloid dental trait (Chung et al.,'72; Niswander,'67).

Table 2

Distribution of Missing and Anomalous Maxillary Lateral Incisors in the Gray Site

	N	Cong. Abs.	Anomalous	Both
Teeth	111	1.0	17.1	18.1
Individuals	59	1.7	20.3	20.3

Table 3

Sex Distributions of Missing and Anomalous Maxillary Lateral Incisors in the Gray Site

	Male	Female	Indet. Sex
Anomalous (bilateral)	4	2	1
Anomalous (unilateral)	2	2	1
Agenesis (unilateral)	0	1	0
Totals	6	4#	2

- one female with anomalous and missing lateral incisor.

Mesial-palatal Version

Winging of the maxillary central incisors is reported to vary between 22-38% among American Indians, with lower incidences in Japanese (10%) and Caucasians (3%) (Dahlberg,'63). Prehistoric Aleut (Turner,'67a) and some South American Indian populations (Campusano et al.,'72; Rothhammer et al.,'68; Wright,'42) exhibit high frequencies of the trait (41.0-82.5%). The causes of the mesial palatal version are not clear. Leigh ('37) reported the occurrence of the trait in cases where the torsion occurs with no indication of incisor crowding. The illustrations of Oschinsky ('61) of Eastern Canadian Eskimo palates show winging of the central incisors associated with "instanding laterals" which he attributes to crowding of the maxilla in relation to the size and number of teeth (Oschinsky and Smithurst,'60). Crowding in Eastern Canadian Eskimo palates varies from 22-40%.

Dahlberg ('63) found in a majority of cases that crowding was not necessary for the trait to occur. The very rare incidence of incisor rotation among Negroes and North American Caucasoids (Oschinsky,'61) argues for the status of winging as a Mongoloid trait (see Niswander,'67).

Winging of the central maxillary incisors is found to occur in 22.7% of Gray site inhabitants (N=22). Two cases are unilateral while the others are bilateral occurrences of

winging. Obvious crowding is not present in the maxillae examined.

Crowding in the Premolar Region

Niswander ('67) has presented the only known population study on transposition of maxillary canine and first premolar. Among the Xavante, one bilateral and two unilateral cases were observed, with a frequency of 0.18%. Tables 4 and 5 show the distribution of the types of crowding observed in the present study. Instances of transposition, impaction of canines and canine crowding may all be the result of the same factors. Lasker ('45), in passing, has noticed cases of canine crowding among the Chinese.

In the mandibular premolar region a significant number of first and second premolars are either rotated or crowded. Crowding is predominantly in the area of the second premolar and is principally directed to the lingual aspect. Instances of rotation are not to be confused with 180 degree rotation reported by Greene ('67b) in ancient Sudanese. In the present study all cases of rotation involve no more than 30 to 45 degrees and generally appear to be associated with mandibular crowding. Moorrees and Reed ('54:87), however, note that mandibular crowding may occur in both large and