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Bioarchaeological Investigation of the Ancient Population Structure of Mayapán

Research Year: 2005
Culture: Maya
Chronology: Late Postclassic
Location: Yucatán, México
Site: Mayapán

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Abstract

The following report presents findings from the first in-depth analysis of the human remains from Mayapán, Yucatán, México, recognized as the most important Maya city of the Late Postclassic period (c.a. 1200-1450 A.D.) (Peraza Lope, 1999). This interdisciplinary project utilized bioarchaeological methods to independently test ethnohistoric accounts of the ancient population structure of Mayapán. Based on a generous grant in 2004 from the Foundation for the Advancement of Mesoamerican Studies, Inc., (FAMSI Grant #05033), dental remains were analyzed for metric and nonmetric trait variation. While metric analyses suggest relative homogeneity of tooth size, nonmetric analyses were able to distinguish groups. The latter analyses identified statistically significant differences between low and high status burials, suggesting status differences corresponded with genetic differences. This was expected given ethnohistoric accounts ascribing foreign origins to the most powerful social groups at Mayapán, such as the ruling Cocom or their rivals the Tutul Xiu. Significant differences were also found between low status burials and mass graves, which are believed to consist of the remains of victims of sacrifice or war. This finding was also expected given ethnohistoric accounts of the massacre of the Cocom in revolts that led to the fall of Mayapán. One of these mass graves presents a pattern of rare nonmetric traits suggesting the presence of several closely related individuals. This mass grave is located in the Itzmal Chen secondary civic/ceremonial center, which is hypothesized to be associated with the K'owoj (Masson, 2003; Pugh, 2003), providing the best potential to date for identifying a historically known group in actual human remains at Mayapán.

Resumen

Este informe presenta los resultados del primer análisis detallado de los restos humanos de Mayapán, Yucatán, México, considerada la ciudad maya más importante del período Posclásico Tardío (c.a. 1200-1450 d.C.) (Peraza Lope, 1999). En este proyecto interdisciplinario se utilizaron los métodos bioarqueológicos para examinar en forma independiente la estructura poblacional de Mayapán mencionada en las fuentes etnohistóricas. Gracias a una beca en el 2004 de la Fundación para el Avance de los Estudios Mesoamericanos, Inc. (FAMSI, #05033), fue posible analizar la variación entre los rasgos dentales métricos y los no métricos. Los análisis métricos sugieren homogeneidad en el tamaño de los dientes, mientras que los análisis no métricos permitieron hacer distinciones de grupos. Con los análisis no métricos se identificaron diferencias estadísticamente significativas entre los entierros de bajo y alto estatus, sugiriendo que las diferencias de estatus se corresponden con las diferencias genéticas. Este resultado es el que anticipábamos en base a las fuentes etnohistóricas, las cuales atribuyen los orígenes extranjeros a los grupos sociales más poderosos de Mayapán tales como los gobernantes Cocom o sus rivales, los Tutul Xiu. También se encontraron diferencias significativas entre los entierros de bajo estatus y las fosas comunes. Se piensa que las fosas comunes albergan los restos de las víctimas de

sacrificios o de la guerra. Este resultado es el que también se esperaba, de acuerdo con las descripciones etnohistóricas de la masacre de los Cocom que terminaron con la caída de Mayapán. Una de las fosas comunes muestra un patrón de rasgos no métricos extraño que sugiere la presencia de parientes. Esta fosa común está ubicada en el centro cívico/ceremonial secundario de Itzmal Chen, el cual supuestamente estaría asociado con los K'owoj (Masson, 2003; Pugh, 2003). Como resultado, proporciona el mejor potencial hasta la fecha para identificar un grupo ya conocido a través de las fuentes etnohistóricas entre de los restos humanos que se encuentran hoy en Mayapán.

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Previous Bioarchaeological Studies

Bioarchaeological investigations of the Maya are relatively new, most osteological studies having focused mainly on descriptive analyses of human remains (Jacobi, 2000). Dental nonmetric studies of the Maya are even rarer, with only four reports published prior to the 1990s (Austin, 1970; Austin, 1972; Austin, 1978; Saul, 1975), though recent years have seen this trend reverse (Angel *et al.*, 1993; Cucina and Tiesler, 2004; Cucina *et al.*, 2003; Jacobi, 2000; Lang, 1990; Pompa y Padilla, 1990; Scherer, 2004; Wrobel, 2003). Teeth are often preserved in the Maya area, despite the generally poor skeletal preservation, hence they are the best source of genetic data on the ancient Maya.

In-depth bioarchaeological investigation of the Mayapán (Figure 1, shown below) material began with the initiation of my dissertation research in 2003, of which this dental study forms an integral part, though several earlier osteological studies have examined remains excavated by the Carnegie Institution of Washington. They include that of Fry (1956), a recent study of cranial deformation practices across the Maya area that included 10 intact crania from Mayapán (Tiesler Blos, 1998), and synopses of ancient Maya burial practices (Ruz Lhuiller, 1965; Ruz Lhuiller, 1991; Ruz Lhuillier, 1968; Tiesler Blos, 1998).

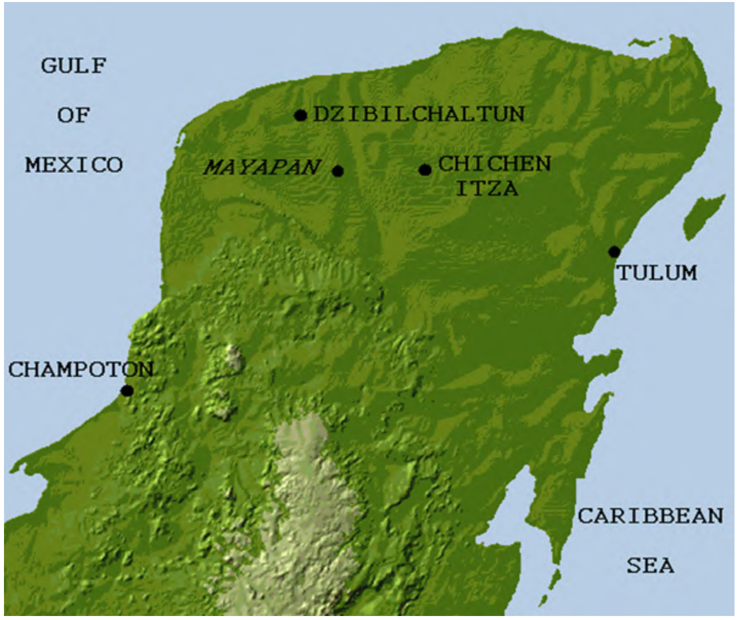

Figure 1. Map of Yucatán Peninsula showing location of ruins of Mayapán (Adapted from Avalon Basemap, copyright 2004).

My research thus far demonstrates that the Mayapán human skeletal series is relatively large for the Maya area and therefore appropriate for testing numerous hypotheses regarding the nature of population structures during the Late Postclassic period. Based on analyses conducted in 2003, the remains of at least 124 individuals were excavated between 1996 and 2003 by Mexican archaeologists of the National Institute of Anthropology and History (INAH) under the direction of Carlos Peraza, at least six individuals between 1999 and 2003 by INAH and State University of New York (SUNY) Albany archaeologists under the direction of Peraza and Marilyn Masson, and at least one individual as part of the dissertation research of Clifford Brown (1999).

The distributions of different modes of burial across Mayapán suggest the presence of disparate groups occupying different sectors of the city (Masson, 2003; Peraza Lope, 2003). Analyses demonstrate that Structure Q-88c, a shrine prominently located in the main plaza (Peraza Lope *et al.*, 1998), houses the crania of at least 9 individuals of various ages, including two old males (Serafin and Peraza Lope, 2005), reminiscent of the Spanish friar Diego de Landa's description of Cocom burial practices involving decapitation and retention of the skulls of revered ancestors (Tozzer, 1941:131). One cranium even presents sharp force trauma on its left mastoid process that may have resulted from attempts at decapitation, though trauma analysis is ongoing. On the other hand, in structure Q-54, located in a different part of the site center, the emerging pattern is of adults buried individually and fully articulated. The data generated by this study were used to determine if these differences in burial pattern correspond with genetic differences.

Materials

The dental remains of over 107 individuals were analyzed for the present study. These remains were divided into three samples based on contextual data so that archaeological hypotheses could be tested. These three samples are referred to here as Local, Elite, and Mass Grave. The Local sample comprises human remains from low status contexts from various parts of Mayapán. Most of these burials are individual, primary, and were placed directly in the ground or Cenote San José without any associated artifacts (Peraza Lope *et al.*, 2004, 2003a, 2003b, 2002, 1999, 1998, 1997; Masson and Peraza Lope, 2002; Brown, 1999; Uc Gonzalez, 1998). The only context with mortuary architecture is a rectangular stone ossuary in the small residential structure Q-94. Importantly, no evidence of peri- or postmortem violence was found in the Local sample (Serafin and Peraza Lope, 2007).

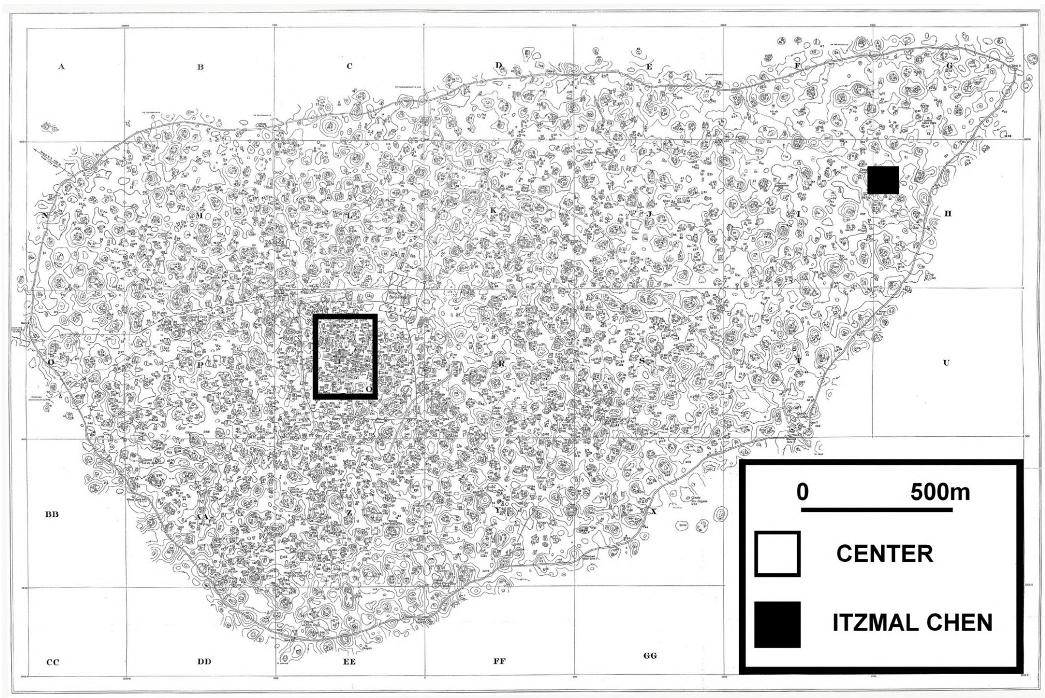

Figure 2. Map of Mayapán showing location of main site civic/ceremonial center and secondary center Itzmal Chen (Adapted from Jones, 1952).

The Elite sample in contrast consists of burials from high status contexts. These were found in the site center (Figure 2, shown above) as well as in outlying areas associated with colonnaded halls or shrines (Peraza Lope *et al.*, 2004, 2003a, 2003b, 2002, 1999, 1998, 1997; Peraza Lope, 1998). Several of the shrine burials were in the form of ossuary cysts built into the structures. The majority of these remains are secondary in nature and do not present evidence of trauma (Serafin and Peraza Lope, 2007), with the one exception in shrine Q-88c noted above.

The Mass Grave sample consists of human remains from the site's main civic/ceremonial center as well as one deposit from the secondary center (Figure 2) located near Cenote Itzmal Chen (Peraza Lope *et al.*, 2004, 2003a, 2003b, 2002, 1999, 1998, 1997; Masson and Peraza Lope, 2003). Each deposit represents numerous individuals and in nearly all cases was found near the surface. Most of these remains are highly fragmentary, consisting mainly of long bones, though relatively complete individuals and parts of individuals were sometimes found interspersed in the same deposit. This sample presents the highest concentration of peri- and postmortem violence (Serafin and Peraza Lope, 2007) and is believed to represent the victims of human sacrifice or war (Masson and Peraza Lope, In press; Peraza Lope *et al.*, In press).

Methods

Dental nonmetric methodology is based on the Arizona State University (ASU) dental anthropology system (Turner *et al.*, 1991) with modifications by Jacobi (2000). The ASU system provides scoring procedures and reference plaques that aid in identifying presence and expression of nonmetric traits (Wrobel, 2003). Observations for each dentition were recorded directly into a computer database, eliminating the time-consuming extra step of first entering data onto a data sheet.

Dental nonmetrics were used for biological distance for several reasons. Teeth preserve better than other parts of the skeleton in the Maya area. Dental nonmetric traits have demonstrated utility in the analysis of genetic relationships between populations, within a population, and sometimes even at the familial level (Jacobi, 2000; Rhoads, 2002:152); and have allowed identification of a Maya dental trait complex (Jacobi, 2000; Wrobel, 2003), which distinguishes the Maya from other Mongoloid, Sino-American, and Mesoamerican populations (Wrobel, 2003). Crania, on the other hand, are often in fragmentary condition and/or artificially deformed (Tiesler Blos, 1998), as is the case at Mayapán. Ancient DNA analyses hold promise (Merriwether *et al.*, 1997) but are still largely unproven in the Maya area.

Dental metric methodology for maximum tooth diameters is based on Hillson (1996), Jacobi (2000), Frayer (1978), Goose (1963), Moorrees (1957), Selmer Olsen (1949), and Wolpoff (1971). Tooth crown diameters were measured with Mitutoyo sliding calipers calibrated to .05 mm for both permanent and deciduous teeth, though only permanent teeth were included in the main analysis. Mesiodistal diameters were measured with the caliper's sharpened tips to fit between teeth still in the jaw (Hillson, 1996). For buccolingual diameters the caliper's beam was held parallel to the occlusal surface of the tooth while the broad flat caliper arms were applied to the crown's buccal and lingual sides (Hillson, 1996).

Tooth diameters were also taken at the cervico-enamel junction (CEJ), as these measurements are less susceptible to wear, thus yielding larger sample sizes, and provide comparable results (Serafin, 2006; Hillson et al., 2005). Methodology followed

Hillson et al. (2005). A subset of maximum and CEJ measurements was taken twice to facilitate testing for intraobserver error.

Dental Nonmetrics–Data Preparation

Before data analysis could be performed it was first necessary to test for errors and other confounding factors. All data were checked to make sure no scores that fall outside the possible range were given by mistake.

The individual count method (Turner, 1985c; Turner and Scott, 1977) was used to maximize sample size and combine scores for left and right sides for each trait for each individual. Where both left and right sides were scored, the maximum expression of the trait was used. Where only the left or the right side was scored, that score was used. This method assumes that it is best to score the maximum expression of a trait for an individual and that side asymmetry is random.

Traits were eliminated that exhibited high intraobserver error. To facilitate testing for intraobserver error, a select subsample of teeth were scored during two separate data collection sessions. Following the methodology of Nichol and Turner (1986), traits were considered problematic if they exceeded the critical value for two or more of the following 3 tests:

- >10% of traits scored differently by more than one grade
- Net Mean Grade Difference (NMGD) > the maximum grade of the trait multiplied by 5
- Paired Sample Student's T-Test, significant at $p<.05$

Several additional intraobserver error indices are recommended by Nichol and Turner (1986) and were calculated:

- % of traits scored in only one session
- % of traits scored differently
- Absolute Mean Grade Difference (AMGD)

Four traits exhibited excessive intraobserver error and were eliminated from further analysis: double-shoveling of the upper canine, Carabelli's cusp of the upper first molar, protostylid of the lower first and second molars.

Traits were dichotomized into presence or absence, as required by most statistical analyses. For traits that were assigned a score along a graded scale, this involved choosing a breakpoint. Though most researchers (see, for example, Rhoads, 2002:137) use the breakpoints proposed by Turner (1986), the methodology of Scherer (2004) and Nichol (1990) was followed here to develop a Mayapán-specific dichotomization scheme. This allowed the maximization of variability when comparing the relatively closely related groups under study here.

First, the dental series was divided into the three samples of interest. Frequencies were then calculated at each grade of a trait for each sample. The grade that produced the greatest difference in frequency between any two samples was chosen as the breakpoint for that trait.

Once the nonmetric data were dichotomized, they were tested for sex effects. This is necessary to demonstrate that sex is not a factor and thus data from males and females can be pooled to maximize sample size. Independent Samples T-Tests were performed to identify traits that varied according to sex. None of these tests was significant.

Dental Nonmetrics–Data Analysis

Dichotomized dental trait frequencies are presented in Table 1 below. Moderate frequencies are expected for a majority of traits, due to the Mayapán-specific dichotomization scheme (Scherer, 2004:118).

Next, traits were identified that vary significantly between the Elite, Local, and Mass Grave samples using Independent Samples T-Tests. Following the recommendation of Harris and Sjǿvold (2004), only those traits that produced at least one significant difference between the samples were included in the MMD multivariate analysis that follows. Of the 101 traits tested, 25 varied significantly between at least two samples. The remaining 76 were excluded from further analysis.

Only one tooth was used for each trait in multivariate analyses (Scott and Turner, 1997; Turner*, et al.,* 1991). For example, shoveling of the upper central and lateral incisors is believed to be controlled by the same underlying genetic factors. Thus, including both traits in multivariate analyses would exaggerate the influence of these factors. Additionally, traits with relatively larger sample sizes were selected.

The Mean Measure of Divergence (MMD) is the most commonly used statistic for measuring biological distance with nonmetric data. MMD values were calculated using the modifications proposed by Green and Suchey (1976). MMD values were calculated using a set of 10 traits, $n \geq 8$, and a set of 5 traits, $n \geq 10$. Table 2 lists the traits employed. Significance at $p < .05$ was achieved when MMD values divided by their standard deviations were greater than 2.0 (Sjøvold, 1973). Table 3 lists the results of the MMD analysis.

Analyses with 10 traits and 5 traits produced comparable results. In both sets of comparisons, the Local sample differed significantly from the Elite and Mass Grave samples. Neither test was able to distinguish the Elite from the Mass Grave sample.

Rare occurrences of dental nonmetric traits can also identify closely related individuals (Jacobi 2000), a particularly useful property when the samples of interest are too small to test using the MMD statistic. Rare traits include the Uto-Aztec premolar and odontome, which occur once in elite residential structures R-106 and R-183b, respectively, but no where else at Mayapán.

Peg-shaped maxillary lateral incisors were only observed in burials 53 and 54. Both burials are single, primary, and were placed directly in the ground near small residential structure Q-67. Both were classified as locals.

The only two cases of congenitally absent lower central incisors occur in skeletons recovered from Cenote San José, which is located outside the site center.

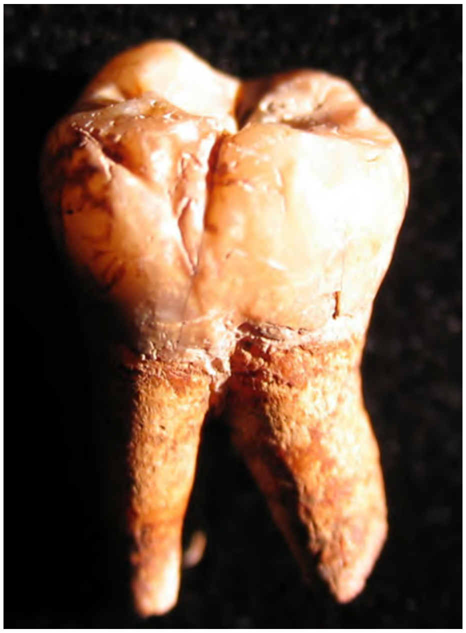

Figure 3. Image of mandibular left third molar from Itzmal Chen mass grave exhibiting unusual protostylid morphology.

The protostylid of the mandibular third molar is most frequent, by far, in the Itzmal Chen mass grave, occurring in four out of four third molars at grade 5 expression or higher. In addition, a number of protostylids on first, second, and third molars in this deposit share an unusual morphological feature: rather than being associated with the main buccal groove that separates cusps one and three, as is the norm, they are associated with an additional vertical groove located mesial to the main buccal groove (Figure 3, shown above). Only two molars outside the Itzmal Chen mass grave display similar protostylid morphology in the entire Mayapán assemblage. It occurs in one M3 (out of three) in elite residential structure Y-44 located outside the site center and one M3 (out of two) in the remains recovered from Cenote San José.

Additional features further mark the uniqueness of the Itzmal Chen mass grave's dental morphology. Enamel extensions on molars occur more frequently in this deposit than any other, and the only observed enamel extension on a premolar also occurs in this deposit. Likewise, the only lower premolar with two roots was observed here.

Implications of these findings are discussed below in the Discussion section.

Dental Metrics–Data Preparation

As with the dental nonmetrics, it was first necessary to test for errors and other confounding factors before analysis of the metric data could be performed. A subset of measurements was taken on two separate occasions to facilitate testing for intraobserver error. A T-test was performed to identify measurements that differed significantly between the two sessions. The average intraobserver error for all measurements combined was .00613 mm (std. dev. = .34004), which is comparable to that found by other workers (Scherer 2003; Stojanowski 2001). Individual measurements with statistically significant intraobserver error were excluded from further analysis.

To maximize sample size, measurements for the left and right sides were pooled. Where a measurement was taken on both antimeres, the left side was used. Where only the right tooth was measured, its measurement was used. This method assumes that side asymmetry is random.

Measurements whose data were not normally distributed were eliminated. To accomplish this, the Kolmogorov-Smirnoff Test was used with Lillifors Significance Correction.

Measurements that were significantly correlated with age were eliminated. During data collection, every effort was made not to take measurements that might have been affected by tooth wear. In addition, studies have shown that, in some populations, individuals who died as subadults have smaller teeth (Guagliardo 1982; Simpson, *et al.* 1990).

Sexes were pooled for all samples. As Stojanowski (2001) notes, this can be done for fragmentary samples, such as the one under study here, under the assumption that the probability of missing data is independent of sex.

Table 4 below lists the measurements that were excluded from further analysis due to intraobserver error, non-normal distribution, or age effects.

The multivariate analyses used in this study (MANOVA, Mahalanobis distance) require complete datasets. However, in fragmentary remains, such as those in the current study, almost every individual was missing data. As a result, missing values had to be estimated. This was achieved using the multiple imputation technique following the methodology of Scherer (2004).

In addition, to prevent allometric effects and size differences due to sexual dimorphism, Q-mode correction of the data was carried out as suggested by Corruccini (1973). For each skeleton an individual size reference variable was obtained by calculating the geometric mean of all the measurements of that individual. Each measurement was then divided by this reference variable.

Dental Metrics–Data Analysis

Significant differences between sample means and variances were tested for using univariate (ANOVA) and multivariate (MANOVA) statistics. For ANOVA, the original dataset was used after excluding measurements with significant intraobserver error, age effects, and non-normal distributions. These results are presented for maximum diameters, as well as those taken at the cervico-enamel junction (CEJ), in Table 5 below. One maximum diameter's variance was significantly non-homogeneous between samples, while this was the case for two different CEJ diameters. Results were more consistent for sample mean differences: the maximum and CEJ mesio-distal diameters on the mandibular third molar were significant.

For MANOVA analysis, the imputed, Q-mode transformed dataset was used. The results are presented below in Table 6. Tests for maximum and CEJ diameters were non-significant.

Mahalanobis distances were calculated between the elite, local, and mass grave samples. Following the methodology of Defrise-Gussenhoven (1967), distances greater than $\sqrt{(2t-1)}$ are significant, where t = number of variables. Three measurements were used in the final analysis, such that D2 values ≥ $\sqrt{(2*3-1)}$, or 2.236068, are significant. The results are presented below in Table 7. As with MANOVA, no significant differences were found using maximum or CEJ tooth diameters.

Discussion

The present study demonstrates the utility of measuring tooth diameters at the cervico-enamel junction compared with the more wear-susceptible maximum diameters. Calculation of Mahalanobis' distance using maximum diameters was able to employ Elite, Local, and Mass Grave samples of 8, 10, and 10 individuals, respectively, while CEJ diameters produced samples of 17, 13, and 10 individuals, respectively, a 43% overall increase in sample size. Results do not exactly match, which was to be expected as different teeth and individuals were used for each. However, analyses of CEJ and maximum tooth diameters are generally consistent and suggest relative homogeneity of tooth size at Mayapán.

In contrast, multivariate nonmetric analyses identified significant differences between samples, supporting our hypothesis that genetically distinct groups existed in Mayapán society. Dental nonmetric analyses were able to distinguish the Local sample from the

Elite and Mass Grave samples. However, they did not find significant differences between the Elite and Mass Grave samples.

The above results suggest that status differences corresponded with genetic differences at Mayapán. This lends support to ethnohistoric accounts ascribing distinct origins from the local populace to three of the city's most powerful lineages, the Cocom, Tutul Xiu, and Ah Kanul. Comparison with results from isotope analyses will clarify whether genetic differences correspond with different geographic origins.

The largest MMD value was for the Local and Mass Grave sample comparison. This suggests that the victims of sacrifice or war who are believed to makeup the latter sample did not come from the local populace. Rather, some of them may have been high status individuals, as suggested by the inability of multivariate nonmetric analysis to distinguish the Mass Grave from the Elite sample. This would be expected based on ethnohistoric accounts of the massacre of the Cocom by the Tutul Xiu, which lead to the collapse of Mayapán.

The K'owoj present the greatest potential to date for identifying a specific social group or lineage in actual human remains at Mayapán. The mass grave recovered from the Itzmal Chen secondary civic/ceremonial center displays dental morphological evidence suggesting the presence of several closely related individuals. The Itzmal Chen center is located near the eastern gate of Mayapán, which, according to The Chilam Balam of Chumayel (Edmonson, 1982), was guarded by a K'owoj noble. Further, architectural features have been identified that are shared by the Itzmal Chen center and the K'owoj of the Petén Lakes (Pugh 2003). In addition, the Itzmal Chen mass grave was only partially excavated and Masson plans to continue excavation in the near future. This will hopefully increase sample size enough to allow testing of this deposit with multivariate statistical analyses.

Archaeological data suggesting K'owoj presence, in this case in the form of pottery, have also been identified in elite residential structure Y-45a. A burial in nearby elite structure Y-44 displays one of only two instances found outside the Itzmal Chen mass grave of the unique protostylid morphology described above. Isotope analyses of the Itzmal Chen mass grave will help to clarify its relationship to this elite residential complex.

In future studies, dental data now available for Mayapán will be used to perform biological distance analyses with contemporary sites of the east coast, Petén Lakes region, Champotón, and the central Mexican highlands. This will allow us to refine reconstructions of population structure and movements in Late Postclassic Mesoamerica as a whole, while also furthering the identification of specific social groups known from ethnohistoric accounts in actual human remains at Mayapán.

Acknowledgements

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Table 5. Results of ANOVA: Levene’s Test of Homogeneity of Variances and F Test of Sample Mean Differences. C denotes measurement taken at the cervico-enamel junction.
Values in bold are significant at p<.05.

Table 6. Results of MANOVA. Max refers to maximum diameters, CEJ to those measured at the cervico-enamel junction.

Table 7. Mahalanobis distances between Elite, Local, and Mass Grave samples.

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Table 1: Dichotomized dental nonmetric trait frequencies.

TRAIT	TOOTH	FREQ %		TRAIT	TOOTH	FREQ
winging	UI1	9.09		radical number	LC	91.67
labial curvature	UI1	44.90		radical number	LP1	65.79
shoveling	UI1	28.13		radical number	LP2	26.92
shoveling	UI2	28.13		peg-shaped	UI2	3.77
shoveling	UC	83.33		odontome	UP1	0.00
shoveling	LI1	84.85		odontome	UP2	2.78
shoveling	LI2	57.14		odontome	LP1	2.27
double-shoveling	UI1	40.00		odontome	LP2	0.00
double-shoveling	UI2	60.00		congenital absence	UI2	0.00
double-shoveling	UC	22.22		congenital absence	UP2	1.72
interruption groove	UI1	3.13		congenital absence	LI1	4.08
interruption groove	UI2	27.78		congenital absence	LP2	0.00
labial groove	UI1	7.50		lingual cusp variation	LP1	39.39
labial groove	UI2	2.44		lingual cusp variation	LP2	36.00
tuberculum dentale	UI1	53.85		radical number	LM1	48.00
tuberculum dentale	UI2	28.00		radical number	LM2	69.57
tuberculum dentale	UC	72.41		radical number	LM3	28.57
labial groove	UC	0.00		congenital absence	LM3	15.91
distal accessory ridge	UC	26.92		anterior fovea	LM1	48.39
distal accessory ridge	LC	64.29		mid-trigonid crest	LM1	29.27
accessory cuspules	UP1	4.65		mid-trigonid crest	LM2	12.50
accessory cuspules	UP2	5.88		mid-trigonid crest	LM3	16.67
tri-cusped premolar	UP1	1.89		mid-trigonid crest	Lm2	42.11
tri-cusped premolar	UP2	0.00		groove pattern	LM1	20.83

TRAIT	TOOTH	FREQ %		TRAIT	TOOTH	FREQ
metacone	UM1	98.55		groove pattern	LM2	61.54
metacone	UM2	73.17		groove pattern	LM3	90.00
metacone	UM3	64.71		cusp number	LM1	18.33
hypocone	UM1	56.34		cusp number	LM2	12.12
hypocone	UM2	51.22		cusp number	LM3	84.00
hypocone	UM3	17.65		deflecting wrinkle	LM1	45.71
c5 (hypoconule)	UM1	13.43		deflecting wrinkle	LM2	11.54
c5 (hypoconule)	UM2	7.50		deflecting wrinkle	LM3	8.33
c5 (hypoconule)	UM3	14.71		deflecting wrinkle	Lm2	72.22
carabeli's cusp	UM1	45.45		distal trigonid crest	LM1	10.42
carabeli's cusp	UM2	42.11		distal trigonid crest	LM2	2.78
carabeli's cusp	UM3	20.00		distal trigonid crest	LM3	0.00
parastyle	UM1	30.91		distal trigonid crest	Lm2	31.58
parastyle	UM2	8.33		protostylid	LM1	34.38
parastyle	UM3	3.33		protostylid	LM2	92.86
enamel extension	UM1	69.77		protostylid	LM3	32.00
enamel extension	UM2	44.00		c5 (hypoconulid)	LM1	64.52
enamel extension	UM3	34.78		c5 (hypoconulid)	LM2	18.75
root number	UM1	100.00		c5 (hypoconulid)	LM3	86.36
root number	UM2	52.94		c6 (metaconulid)	LM1	21.15
root number	UM3	33.33		c6 (metaconulid)	LM2	13.33
radical number	UM1	73.91		c6 (metaconulid)	LM3	32.00
radical number	UM2	5.88		c7 (entoconulid)	LM1	5.26
radical number	UM3	76.00		c7 (entoconulid)	LM2	2.27
peg-shaped	UM3	6.00		c7 (entoconulid)	LM3	8.00
congenital absence	UM3	12.73		enamel extension	LM1	68.00
enamel extension	UP1	0.00		enamel extension	LM2	12.90
enamel extension	UP2	0.00		enamel extension	LM3	50.00
root number	UP1	8.33		root number	LM1	3.23
root number	UP2	2.78		root number	LM2	71.43
radical number	UI1	33.33		root number	LM3	13.33
radical number	UI2	31.25		root number	LC	0.00
radical number	UC	74.29		tome's root	LP1	52.78
radical number	UP1	100.00		enamel extension	LP1	0.00
radical number	UP2	96.67		enamel extension	LP2	3.03
radical number	LI1	85.19		root number	LP1	2.56
radical number	LI2	3.85		root number	LP2	0.00

Table 2: Dental nonmetric traits employed in calculation of MMD values using 10 traits and 5 traits.

TRAIT	TOOTH	10 traits	5 traits
labial curvature	UI1	x	x
tuberculum dentale	UC	x	
hypocone	UM2	x	x
c5 (hypoconule)	UM1	x	x
root number	UM3	x	
cusp number	LM2	x	
protostylid	LM3	x	
c5 (hypoconulid)	LM1	x	x
c6 (metaconulid)	LM2	x	
enamel extension	LM1	x	x

Table 3: MMD values calculated employing 10 traits and 5 traits.
Significant values are in bold. “MG” refers to the Mass Grave sample.

MMD						
10 TRAITS				5 TRAITS		
SAMPLE	MG	ELITE		SAMPLE	MG	ELITE
LOCAL	0.576306	0.220605		LOCAL	0.428038	0.199092
ELITE	0.142291			ELITE	0.125196	

Table 4: Measurements excluded from analysis.
C denotes measurement taken at the cervico-enamel junction.
E = intraobserver error, N = non-normal distribution, A = age effects.

Measurement	Reason Excluded		Measurement	Reason Excluded
UI2 BL	N		UC BLC	N
UP3 BL	N		UM1 MDC	N
UP4 MD	A		UM2 MDC	N
UM1 MD	E		UM3 MDC	A
UM3 BL	E, N		UM3 BLC	N
LP4 BL	N		LI1 BLC	E
LM1 BL	N		LC BLC	N
			LP4 MDC	N

			LM1 BLC	A

Table 5: Results of ANOVA: Levene's Test of Homogeneity of Variances and F Test of Sample Mean Differences.

C denotes measurement taken at the cervico-enamel junction.
Values in bold are significant at p<.05.

Measurement	Levene	F		Measurement	Levene	F
UI1 MD	1.146075	0.608471		UI1 MDC	4.265288	0.471061
UI1 BL	0.469885	1.531255		UI1 BLC	6.487007	0.289035
UI2 MD	1.137562	2.573253		UI2 MDC	0.124598	0.317307
UC MD	0.337999	0.280131		UI2 BLC	2.643658	1.136301
UC BL	0.943284	2.05511		UC MDC	1.181127	1.819173
UP3 MD	1.203015	0.963876		UP3 MDC	0.590265	1.228287
UP4 BL	1.139676	1.730463		UP3 BLC	0.529916	0.591873
UM1 BL	0.929764	0.476992		UP4 MDC	1.520316	0.048972
UM2 MD	0.735043	1.15979		UP4 BLC	2.366638	0.065013
UM2 BL	0.339463	0.891275		UM1 BLC	0.788483	0.78094
UM3 MD	0.629833	2.457594		UM2 BLC	0.817529	1.374704
LI1 MD	1.965361	0.276334		LI1 MDC	1.652513	0.25726
LI1 BL	0.829044	0.508054		LI2 MDC	0.029649	0.188489
LI2 MD	0.613924	1.115623		LI2 BLC	2.910597	0.056115
LI2 BL	2.145543	0.549347		LC MDC	3.027834	0.257319
LC MD	0.631823	0.119739		LP3 MDC	0.620936	0.344239
LC BL	1.044362	0.478139		LP3 BLC	0.491213	0.045529
LP3 MD	0.096033	0.779339		LP4 BLC	1.46362	0.106175
LP3 BL	0.028101	0.027703		LM1 MDC	0.525858	0.147869
LP4 MD	5.037569	0.058825		LM2 MDC	1.070716	0.425749
LM1 MD	1.346928	0.478594		LM2 BLC	0.410322	0.499016
LM2 MD	0.410565	0.590865		LM3 MDC	1.746613	9.711639
LM2 BL	0.409364	0.924085		LM3 BLC	2.432047	3.648884
LM3 MD	0.166047	4.278376				
LM3 BL	2.63234	1.366722				

Table 6: Results of MANOVA. Max refers to maximum diameters, CEJ to those measured at the cervico-enamel junction.

Diameter	Wilks' λ	F	df	Sig.
Max	0.912104	0.360909	46	0.899771
CEJ	0.783806	1.511118	70	0.187254

Table 7: Mahalanobis distances between Elite, Local, and Mass Grave samples.

Samples Compared	Max	CEJ
Elite vs. Local	0.410661	0.298952
Elite vs. Mass Grave	0.423042	1.396169
Local vs. Mass Grave	0.006721	0.722970