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A Promising Mandibular Molar Trait in Ancient Populations of Ireland

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ABSTRACT A novel morphologic feature on the human dental enamel of the permanent mandibular molars is described. The character, named MMPT (mandibular molar pit-tubercle), is situated mesial and occlusal to the position often occupied by the protostylid on the buccal aspect of cusp 1. Three grades of variation, a pit, a groove, and a tubercle were observed, described and categorized for study. The study groups consisted mainly of archaeological specimens from Ireland, representing approximately 5,000 years of prehistoric and early historic populations on the island, dating from the Neolithic *(ca.* 4,000-1,800 B.C.) through the Early Christian era (*ca.* A.D. 400-1170). All lower molars (representing 432 individuals) were studied, ranging from 129 to 179 scorable molars depending on tooth type. The third molar more commonly expressed all forms of MMPT than the first or second molars, with approximately 30% of all third molars exhibiting a form of MMPT (28% of lower left third molars and 33% of lower right third molars). The most commonly expressed form of MMPT was Grade 1, the pit form, most commonly on third molars. Individual Viking specimens from Ireland also exhibited MMPT, and the trait appears to be present in East Asian modern humans at a markedly lower rate of expression, and in *Homo pekinensis*. Further research will clarify any relationships between MMPT, paramolar tubercles, paramolar structures and the protostylid, as well as the utility of MMPT in dental anthropological biodistancing studies. *Dental Anthropology* 2009;22(3):65-72.

Dental morphological traits have long been recognized for their importance as phenotypic expressions of genetic differences between human groups. Variations in root and enamel structure were noted in the past by dentists, natural historians, and anatomists (*e.g.*, von Carabelli, 1842; Owen, 1845; Tomes, 1889). Physical anthropologists and dental anthropologists have continued to discover, describe and categorize new forms of dental trait variation (Hrdlička, 1920; Gregory and Hellman, 1926; Weidenreich, 1937; Dahlberg, 1950; Morris, 1975; Scott, 1977; Morris *et al*., 1978; Harris and Bailit, 1980; Burnett, 1998; Yamada et al., 2000; Correia and Pina, 2002; Edgar and Sciulli, 2004).

Rates of expression for many morphological traits have been recorded in various human population groups. These data have been used to search for patterns of affinity between world regional groups since the beginning of the discipline (*e.g.*, Hrdlička, 1921; Hellman, 1929; Dahlberg, 1945a, Carbonell, 1963; Morris, 1970; Scott, 1980; Scott and Turner, 1997; Hanihara, 2008). But there has been a general imbalance in information for these comparisons. Populations of eastern Asia, the Americas and the Pacific have received much attention over the years (*e.g.*, Wissler, 1931; Kraus, 1959; Suzuki and Sakai, 1964; Kolakowski *et al*., 1980; Haydenblit, 1996; Swindler and Weisler, 2000; Tocheri, 2002, Matsumura and Hudson, 2005). Fewer studies of European (*e.g.*, Jørgensen, 1955; Axelsson and Kirveskari, 1977; Toth, 1992; Ullinger, 2002, Coppa *et al*., 2007) and African (*e.g.*, Hassanali, 1982; Irish, 1997; Guatelli-Steinberg *et al*., 2001; Irish, 2005) groups have been undertaken. While the study of tooth morphology has a rather lengthy history as a sub-field of physical anthropology (Scott and Turner, 1988; Dahlberg, 1991; Scott and Turner, 1997), it is likely that discoveries of novel traits or under-reported variation will be made as new groups, especially in these less-studied regions of the world, are investigated.

It appears that previously unreported variation in an enamel morphological character exists in ancient populations of Ireland. The author noted this variation during a dental anthropological research project that sought to

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assess, through the use of the Arizona State University Dental Anthropology System (ASUDAS), the presence of large-scale migrations in ancient time periods of Ireland (Weets, 2004). While recording morphometric variation in specimens from several times periods dating from Ireland's Neolithic (*ca*. 4,000-1,800 BC) to its Early Christian era (*ca*. AD 400-1170), an indentation in the enamel crown was first noted on the buccal surface of heavily fragmented and cremated permanent mandibular molars from multi-component megalithic tomb sites.

Initially, this indentation was thought to be a variant of a weak form of the protostylid, which simply had not been described in publications on the ASUDAS (Turner *et al*., 1991). In addition, the indentation often was not noticed because it was not in the correct location for a protostylid, which was one of the traits scored in the broader research project. Eventually, the discovery of an individual with both a weak grade of protostylid and this indentation on the mandibular molars prompted a closer investigation of this characteristic (Fig. 1).

Observing several specimens, it was found that the indentation was most often in the form of a small pit; a pinpoint circular area of enamel agenesis situated a good distance mesial from the buccal groove. The pit tends to be located high on the buccal surface of the lower molars, suggesting a high likelihood for destruction of the character with even moderate buccally-directed lower tooth wear. This pit differed significantly from the ASUDAS grade 1 buccal pit of the protostylid, located in the buccal groove, as depicted on the ASUDAS protostylid cast and described by Turner *et al*. (1991). Considering its most common form and the geographic setting, it was noted by the author as the "Irish mandibular molar pit" (IMMP) during data collection and in publication of his Ph.D. thesis (Weets, 2004). The character, in all its forms, will be referred to as MMPT (mandibular molar pit-tubercle) for the remainder of this article. This label encompasses the range of variation; it avoids ethnic labeling commonly seen in the ASUDAS system; and it allows for any relationship with complex forms of paramolar tubercles that future research may reveal.

The Morphological Variation

Morphological variation was categorized into three grades that represented the most commonly observed forms of the trait. Assuming that MMPT was either a new trait or had not been reported, other less common forms were assigned to intermediate grades. The intent in the formation of three major grades and of intermediate grades was to provide the fullest description of the trait to inform dental researchers. The accumulation of more data on MMPT variation will likely show some of the intermediate or major grades to be superfluous for biodistancing studies. For those who wish to incorporate the MMPT into a biodistancing study, although this may be premature, the author would suggest application of the same methods as are used with the ASUDAS. Only the three major grades of MMPT would be used, with systematic assignment of intermediate variation to the lower grade of variation (*e.g*., MMPT Grade 1-2 assigned to MMPT Grade 1) or, in a case of identifying presence of the trait, assignment to the first major grade (*i.e*., MMPT Grade 0-1 is assigned to MMPT Grade 1). It may be that MMPT proves to have rather clear gradations in morphology that account for its full range of variation, so that a graded plaque for the ASUDAS could be produced. More more research on other populations is necessary to ultimately refine these embryonic categorizations of MMPT variation described below.

Fig. 1. Grade 1 of MMPT present on second and third left lower molar as shown by downward-pointing arrows (buccal view). Note presence of a weak form of the protostylid on second molar as shown by upward-pointing arrow. Mesial is to the left of the photograph.

Fig. 2. Grade 2 of MMPT on lower left third molar (buccal view).

Grade 1 of the feature was assigned to the aforementioned small pit, located mesially and high on the buccal surface of cusp 1 of the lower molars (Fig. 1). The pit was approximately 0.5 to 1 mm in depth. It was often located approximately 1-2 mm below the intersection of the buccal and occlusal planes, and approximately 1-2 mm from the intersection of the mesial and buccal faces. While the vast majority of pits encountered during the study were consistent in their location, depth and form, it was not always easy to detect the presence of the character. Several individuals had a slight depression or indentation in the position often occupied by the pit. These were categorized as Grade 0-1 of MMPT to acknowledge what appeared to be a weak expression of the pit form of the trait.

Grade 2 was a groove with its superior terminus approximately in the position often occupied by a Grade 1 pit. From this point, the groove ran in a distal-inferior direction at approximately a 30-45 degree angle to the occlusal plane (Fig. 2). In some cases, the superior terminus was a pit with the groove extending in an inferior, distal direction from it. There were a handful of cases where the groove was quite short in its inferior-distal extension, making the "mouth" of the pit elongated. These were classified as Grade 1-2.

Grade 3 has the form of a tubercle without a free apex. Fig. 3 portrays this tubercle, situated mesially on the buccal surface. This photograph shows the strongest expression of a Grade 3 cusp that was encountered during the study. Note that there is no involvement with the tooth's buccal groove (between cusps 1 and 3), even though the MMPT cusp is rather sizeable. In fact, though not quantified, there seemed to a relatively common tendency in these specimens from Ireland for a very weak expression of the buccal groove, or complete lack of the buccal groove, on lower molars.

There were other expressions of the character greater than Grade 2 that appeared to be the beginning of the tubercle present in Grade 3 (Fig. 3). From the position occupied by the pit in Grade 1, a groove ran inferiorly, giving the appearance of a small tubercle separating from the buccal face (Fig. 4). Situated about 1 mm distal to this groove was a pit. This pit was not in contact with the buccal groove as a protostylid would be, but the pit was lower on the buccal plane of the crown and more distally-situated than the pit from Grade 1. It appears to demarcate the distal side of a weak tubercle, though not as well-formed as in Grade 3 (Fig. 3). Several cases were encountered that were placed in this Grade 2-3 category.

It should be noted that even with categorization of MMPT, distinguishing between MMPT and the protostylid could be difficult. In three cases in the study, distally-directed grooves originating from areas high on the buccal surface of cusp 1 intersected the buccal groove separating cusps 1 and 3. If one were to have no knowledge of the MMPT character, these grooves intersecting the buccal groove would be most likely assigned to a form of the protostylid. Because of the uncertainty in assignment, these cases were subsequently dropped from consideration in this study as forms of MMPT, and in the greater study as protostylids, though all three cases seemed to be more related in form to the protostylid. Further research on the MMPT trait may provide clues helpful in discerning its more complex forms from those of the protostylid.

Fig. 3. Grade 3 of MMPT on the lower left third molar of this individual (buccal view). The left arrow points to the mesial groove, and the right arrow points to the distal groove. In combination, these two grooves are marginal limits of this feature.

Fig. 4. Lower right second molar exhibiting grade 2-3 of MMPT (buccal view). Note the distally-situated pit mesial to the buccal groove and the sulcus forming at the mesial aspect of the enamel crown. Mesial is to the right of the photograph.

Geographic and Temporal Distribution

A review of the literature revealed no report of the range of morphological variation described above for the MMPT. In response to a query, Dr. Christy Turner (pers. comm.) kindly brought to the author's attention an illustration of a similar-looking character on Plate XVI (Fig. 139b of Sinanthropus 36) of Weidenreich's (1937) classic work on *Sinanthropus pekinensis*. However, no written description of that character could be found in Weidenreich's work. Looking further it seemed that other plates also had drawings depicting what appeared to be the same character. These include Plates XVIII (Fig. 148b of Sinanthropus 99), XIX (Fig. 172b of Sinanthropus 114) and XX (Fig. 177b of Sinanthropus 52). Dr. Turner (pers. comm.) also commented that he had observed the character before in his research but had found them at such a low percentage in Asian and Asian-derived populations, where he has done much of his research, that he had not pursued it further. Dr. Joel Irish (pers. comm.), in a discussion of photographs of MMPT with the author, commented that he had recently observed the pit form of MMPT in a Euro-American male student in Alaska, but did not know what the character was when he observed it in that individual, nor had he encountered it before in his research, which includes a number of African groups.

Paramolar tubercles

Although the range of variation of MMPT does not seem to have been described, publications about other traits appearing on lower molars in the general location of MMPT give cause for caution in suggesting that the trait is unreported. Dahlberg states "the paramolar cusp of Bolk, which is found occasionally on the mesial portion of the buccal surface of lower molars, occurs but rarely on the first molar, more often on the second and third" (1945a, p. 682).

Bolk (1916), in his description of the paramolar tubercle, or paramolar cusp, was not only talking about a cusp forming on the buccal surface of lower molars, but also on the buccal surface of upper molars. As summarized by Dahlberg (1945b), Bolk's contention was that supernumerary teeth, called paramolars, which occasionally appeared buccal to and between the first and second, and second and third molars, were atavisms representing a fuller set of posterior deciduous dentition that had been lost in evolution. These paramolars, when they were not expressed as supernumerary teeth, were thought by Bolk to sometimes join with the permanent molars during development, thus resulting in a cusp found on the anterior-buccal portion of the second and third molars. It was further argued by Bolk (1916) that he had never seen a paramolar tubercle on a first molar in his study of 20,000 cases. In contrast, Dahlberg (1945b) provided several examples of Bolk's paramolar tubercle on lower first molars, as well as an example of paramolar tubercles on all six lower molars. Also, to provide for better terminology, Dahlberg (1945b) suggested that Bolk's paramolar cusp be called a "parastyle" on upper molars and a "protostylid" on the lower molars. These are two traits that are, of course, present in the ASUDAS.

In his 1950 article, Dahlberg returned to the subject and further refined his definition of the protostylid: (1) that it is unrelated to other analogous paramolar structures known generally as "paramolar cusps," (2) that it is associated with the buccal groove, and (3) that it occurs much more commonly on first mandibular molars than do other paramolar structures. With his concentration on the protostylid, Dahlberg left other paramolar cusps an open question. Almost 50 years later, Scott and Turner (1997, p. 47, 53) discuss the parastyle of the upper dentition and state that there is little known about some paramolar structures and there is a lack of research on these traits.

Investigating what has been published on paramolar tubercles, Bolk (1916) provides a number of photographs of paramolar cusps in the upper and lower dentition, but the majority is from an occlusal perspective. While there are clear examples of cusps arising on buccal surfaces, it is impossible to see exactly their expression on the buccal surface and how exactly they differ from protostylids because of the occlusal perspective. One photograph (Bolk's Fig. 15) shows the buccal surface, but the tubercles are of much stronger expression than the variation exhibited in Ireland, and some have involvement with the buccal groove. Therefore, there is still quite a question of how exactly these structures are related. Interestingly, there is a third molar in Bolk's Fig. 22, although he did not mention it, where a pronounced anterior buccal cusp with no buccal groove involvement is portrayed. While some examples of Bolk's paramolar tubercle are likely to be strong expressions of MMPT, there appears to be no previous published information on the range of variation of this mesiobuccal structure as it is exhibited in ancient dentition from Ireland.

METHODS

Human remains from Ireland's Neolithic (*ca*. 4,000-1,800 B.C.), Bronze Age (2000-900 B.C.), Iron Age (700-100 B.C.) through its Early Christian era (*ca*. A.D. 400-1170) was the target group of the greater research project. Also included in this research were a few remains from Viking burials in Ireland, dating from contexts after *ca*. A.D. 830. Mallory and O'Donnabhain (1998) provide an inventory of archaeological sites known to have yielded skeletal remains from these Irish time periods and where they are currently curated. Their document served as a guide for selection of sites, and it was the intent of the greater research project to observe all of their listed sites within these time periods.

In this particular research on MMPT variation, skeletal remains from the holdings of the National Museum of Ireland in Dublin (NMI), the Department of Archaeology at University College, Galway (UCG), the Department of Anatomy at Queen's University, Belfast, Northern Ireland (QUBA), and the Department of Archaeology at Queen's University, Belfast (QUB) were examined. NMI holds the majority of all archaeological human remains from the island, and most of the teeth from this study were examined there.

Across a time span of a few thousand years, there were various mortuary programs, and these distinctive programs sometimes existed at roughly contemporaneous periods. Cremated, secondary burials and inhumed remains were encountered. Deposition of multiple individuals was present in a number of contexts, especially from pre-Christian time periods. There were also a sizeable number of individual inhumations with teeth intact in the mandible, especially from the Bronze Age and the Early Christian period.

In order to systematically study and record MMPT, individuals were separated and dental elements sorted. All lower molars encountered were inspected for the presence of MMPT. Detailed notes describing MMPT were entered in the database on each molar. In addition, the character was assigned one of the three grades using written descriptions, direct comparisons of molars with MMPT variation, and reference to digital photographs. Intermediate examples of variation were assigned grades illustrating the range of variation they encompassed (0-1,1-2, 2-3). Degree of wear was also collected on all molars. In any case where a tooth was too worn, damaged in some manner that the buccal surface could not be examined or were obscured by heavy soil matrix or calculus, the character was assigned a non-score. A 10X hand lens was used to observe trait variation in all lower molars.

The final total of individuals with at least one lower molar was 432. The database was scanned for information collected on MMPT. In three cases, MMPT could not be discerned from expressions of the protostylid and these were dropped from the study. Wear was often quite heavy; antemortem tooth loss was common; and heavy calculus was encountered rather frequently. These factors reduced the study sample by more than half, resulting in between 129 and 179 scorable molars depending on tooth type (Table 1).

RESULTS

Table 1 shows frequency rates of MMPT expression in all measureable ancient teeth from Ireland. The strongest expression is in the third molars where approximately 3 out of 10 individuals exhibited the character (28% of lower left third molars and 33% of lower right third molars). The first and second molars show a decidedly low frequency of the trait with ranges between 0% and 3% of the sample with the character. The most common expression of MMPT is the pit form, with 10% of lower left third molars and 19% of lower right third molars exhibiting this Grade 1. If one were to include the weak indentation form (Grade 0-1) and the elongated pit/short groove form (Grade 1-2) with Grade 1, then 21% of lower left third molars and 26% of lower right third molars have Grade 1 morphology. Percentages for Grade 2 show greater rates of expression of MMPT in the third molar over the first and second molars. In Grade 2-3, second and third molars are essentially equal and in Grade 3, rate of expression is essentially equal for right second and third molars (*ca.* 1%) with greater disparity in rate of expression between left second and third molars (0% *vs.* 2%, respectively).

Three Viking specimens from Ireland not listed in Table 1 were also measured and had a similar percentage of expression—from this decidedly tiny sample—to that of the prehistoric and early historic groups. One specimen (Eyrephort, Co. Galway) had Grade 1 MMPT on its lower left third molar, while its first and second lower left molars had none. A second specimen (Islandbridge, Co. Dublin) had no expression of the trait on its right third molar, the only lower molar representing this individual. The third individual (Kilmainham, Co. Dublin) had two teeth, the left second and third lower molars, which could be scored. The trait present on these two teeth could not be distinguished from a protostylid. This was one of the three cases in the study where a distinction between a protostylid and MMPT could not be made.

TABLE 1. Scorable ancient Irish cases with percentages of character grade expressions by tooth

Tooth[1]	n	Grade 0	Grade 0-1	Grade 1	Grade 1-2	Grade 2	Grade 2-3	Grade 3
LM_1	170	100.0	0.0	0.0	0.0	0.0	0.0	0.0
RM_1	151	97.9	0.0	0.7	0.7	0.7	0.0	0.0
LM_2	178	97.7	0.6	1.1	0.6	0.0	0.0	0.0
RM_2	179	96.6	0.0	1.1	0.6	0.0	0.6	1.1
LM_3	131	71.6	0.8	10.2	9.8	5.3	0.0	2.3
RM_3	126	67.2	1.6	19.4	4.7	5.5	0.8	0.8

[1] Codes are left (L) and right (R) sides.

DISCUSSION

The frequency of expression of MMPT is promising for future application in dental anthropological studies. At least in ancient populations from Ireland, it appears to occur at a rather high frequency, which is somewhat unusual for dental anthropological characteristics in European or European-derived populations. Only traits such as upper second incisor interruption grooves, 4-cusped lower second molars, Carabelli's cusp, 2-rooted upper first premolars and 3-rooted upper second molars as described by Scott and Turner (1997) have rates of expression approximately as high or higher. Many others have rates of expression in only 5-10% of a given European or European-derived population (Scott and Turner, 1997).

One intriguing question is how MMPT is expressed in other populations. Considering European populations, its appearance in at least one of three Viking individuals, all of whom have been suggested to be from populations external to Ireland based on either grave goods or burial context (NMI museum inventory files for Eyrephort, Kilmainham and Islandbridge; Mallory and O'Donnabhain, 1998; Waddell, 2000), promises a high probability that MMPT will be found in other European samples. It may be possible that one, two or all three of these individuals could be Hiberno/Norse rather than Scandinavian Viking, coming from intermarriage between indigenous Irish and Viking populations, and that the trait might be expressed in a given individual because of indigenous Irish parentage. However, the most clear case of MMPT expression in these supposed Viking individuals is seen in the Eyrephort, Co. Galway specimen, who came from a single burial accompanied by a sword, dagger and shield boss of Viking type (NMI museum inventory file) and has long been recognized by Irish archaeologists as one of the clearest examples of a Viking burial in Ireland (Waddell, 2000). Joel Irish's (pers. comm.) recognition of MMPT in a Euro-American student, though the exact descent of that student is not known, provides further evidence that MMPT may be a relatively common trait in European and European-derived peoples.

Another question is the utility of the trait in discerning world regional samples from one another. It may not be possible in European or European-derived populations to use MMPT to distinguish geographic or temporal groups. But, based on a relatively high rate of occurrence in ancient populations of Ireland, a very low rate of occurrence in East Asia (C. G. Turner, pers. comm.) and a trait that had not caught the eye of a researcher in his extensive study of African populations (Irish, pers. comm.) it seems that MMPT would be useful in distinguishing world regional groups from one another. Weidenriech's (1937) depiction of what appears to be MMPT in *Homo pekinensis* suggests that the trait could be useful in paleoanthropological studies as well.

Finally, there is the lingering question of the novelty of the MMPT. While no publication could be found that depicts mesiobuccal mandibular molar morphology ranging from a pit to a tubercle trait, it is certainly possible that these mesiobuccal pits, grooves and tubercles are weak expressions of what have been referred to as paramolar tubercles on the mandibular dentition (Bolk, 1916), with the exclusion of all forms of the protostylid. Interestingly, although Bolk (1916) reported that he had never noted a paramolar cusp on the first molar, which matches well with the pattern of MMPT, he also states that it was much more commonly found on the second molar than on the third. This pattern apparently applied to both the upper and lower molars (Bolk, 1916). This prevalence of Bolk's paramolar tubercles on the second molar runs contrary to the findings of MMPT expression in this study, where it is the third molar that had equivalent or slightly higher rates of expression than the second molar of Grade 3 of MMPT, which is the closest form of variation to what might be viewed as a paramolar tubercle.

Kustaloglu's (1962) research on upper paramolar tubercles (parastyles) suggests a potentially high degree of symmetry in rates of expression between mandibular and maxillary tubercles. Data on the ancient Irish remains shows parastyle frequency rates of expression of only 1.6%, 1.2% and 1.4% for the upper first, second and third molars, respectively. Considering the higher grades of MMPT, Grades 2-3 and 3, this pattern of upper and lower symmetry between a known and a potential paramolar structure holds. For the first and second molars on all grades of the MMPT, there are similarly low (or nonexistent) rates of expression that reflect the pattern of expression for the parastyle. However, in the lower grades of MMPT, when the third molar is considered, there is significant dissimilarity. Furthermore, there was never an example of a similar mesiobuccal pit, groove or tubercle structure like the MMPT on the maxillary molars that might reflect the MMPT in the upper dentition of this study population.

Schulze discussed paramolar tubercles and structures: "They appear more frequently on the upper molars … favoring the second and third. As a rule, they are located on the mesiobuccal cusp but can occur farther distally. Their size varies, and frequently a small depression or enamel groove is found in the corresponding place" (1970, p. 99). This last portion of the passage sounds very much like MMPT, but, reading further, Schulze is discussing paramolar structures on both the upper and lower molars, the reference to enamel grooves apparently comes from a 1926 article by Fabian on upper molars that Schulze cites and in focusing on paramolar tubercles that could appear in the lower dentition "on the first molar and, rarely, on other teeth." Dahlberg's 1950 article is cited where clearly the protostylid would be included among these paramolar tubercles (Schulze, 1970, p. 100). What had appeared at first glance to be the best description of characters like MMPT awaits further research to distinguish connections and differences between MMPT, Bolk's paramolar tubercle and the protostylid. And, for that matter, further research of the upper molar parastyle may reveal greater variation in paramolar structures of the upper dentition.

CONCLUSIONS

This report describes the MMPT that is expressed the buccal surface of the mesiobuccal cusp of lower molars. Ths feature occurs in approximately 30% of specimens from Ireland dating from the Neolithic to the Early Christian period. It appears to have a wide geographic and temporal distribution, as it was present in a small sample of Vikings from Ireland, and, apparently, in specimens from ancient eastern Asia, both modern human and older hominid species. The situation of the MMPT trait on the buccal surface of mandibular molars increases its likelihood of surviving dental attrition. Its higher frequency of occurrence on third molars improves chances for observation relative to buccal traits on worn first and second lower molars. The MMPT also has the potential to be one of the more frequently exhibited dental traits known in European and European-derived populations.

Further study of MMPT will clarify its range of variation and determine what connections, if any, it has to Bolk's mandibular paramolar tubercle, the protostylid, or paramolar structures of the upper dentition. The forms of MMPT illustrated in this article suggest a trait that has promise for future dental anthropological studies.

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Stigmata of Congenital Syphilis on a High Status Juvenile at Yuguë, Oaxaca, Mexico

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ABSTRACT Presented here is a case study from Mesoamerica whose dentition resembles the dental stigmata of others who have been described as having congenital syphilis. Found with a green stone bracelet, this child was likely a high-status member of a pre-Colombian population from the Pacific Coast of Oaxaca, Mexico (late Terminal Formative Period, 150 BCE – CE 250). While taphonomic changes precluded in-depth observations of the skeleton, dental traits such as plane-like hypoplastic defect and Fournier's molars are described and compared to previous studies. Additionally, a two-tier system is introduced for describing dental malformations that may suggest either environmental variation in the bacterial assault or in host response. *Dental Anthropology* 2009;22(3):73-84.

There are four treponemal syndromes, as identified by their subspecies of treponematosis, the expression of which differs in relation to environment and, possibly, host responses. Three of these syndromes can affect the skeleton, namely yaws (*Treponematosis pallidum* subsp. *pertenue*), bejal or endemic syphilis (*T.p.* subsp. *Endemicum*), and venereal syphilis (*T.p.* subsp. *pallidum*.), which includes congenital syphilis. In the living, a clinical diagnosis as to which treponemal syndrome a patient may have can be difficult (Landrum *et al*., 2005). In cases where symptoms of one syndrome may mirror the other, DNA analysis aids in differential diagnosis (Centurion-Lara *et al*., 1998; Kolman *et al*., 1999; Landrum *et al*., 2005). With archaeological specimens, a positive identification using genetic testing depends on the amount of available, viable DNA. In circumstances where taphonomic change has affected DNA viability, one must rely on skeletal changes. Patterns of affected bones characteristic of syphilis do aid in diagnosis, but not every case follows the same pattern, thus complicating its identification in the archaeological record (Ortner, 2003). The same has been true of congenital syphilis with one significant exception, the dentition appears to follow a specific pattern when affected.

Transmitted between mother and child during fetal development, congenital syphilis often creates malformations in the developing dentition. These changes to the teeth have been documented in the New World; however, these cases are, frequently, from historic or proto-historic settings (Jacobi *et al*., 1992; Hutchinson and Richman, 2006). Ortner (2003:274) poses the question, "Does the bioarchaeological evidence address the issues of where and when the various syndromes developed?" There is evidence from both sides of the Atlantic Ocean of alledged cases of syphilis of considerable antiquity (Baker and Armelagos, 1988; Hillson *et al*., 1998; Ortner, 2003; Hutchinson and Richman, 2006; Lewis, 2007; Walker *et al*., 2005), and these fuel debate as to its origins.

The majority of physical evidence in the New World, with regard to congenital syphilis is weighted toward changes to the post-cranial elements, with little description of the teeth (Hutchinson and Richman 2006). Powell and Cook (2005) discuss 16 pre-contact North American specimens with evidence of treponematosis. Included are two regions from the interior of Mexico and four sites along the Pacific coast namely, Alaska, Canada, California, and Baja California, Mexico. The origin for the individual under discussion is the Pacific coastal site of Yugüe, Oaxaca, Mexico.

Here, evidence is presented from a New World case of an individual whose patterns of dental change possibly reflect congenital syphilis. The condition of these archaeological remains restricts this analysis to the teeth and leaves few or no clues elsewhere in the skeletal remains. Dental traits characteristic of this disease are described here and are compared to previous studies.

DENTAL MALFORMATIONS DUE TO CONGENITAL SYPHILIS

Recent studies on cuspal enamel hypoplasia (CEH) have focused on the disruption of the enamel matrix formation that occurs at the inception of crown development (Ogden *et al*., 2007). Such enamel defects are

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Fig. 1. Labial view of the central maxillary incisors showing patchy hypoplastic defects on the midcrown (right central incisor) and a heart-shaped incisal outline of the crown (left central incisor). The specimen's left maxillary central incisor is on the right of the photograph; the right central is on the left. Scale is in millimeters.

Fig. 2. Lingual view of the central maxillary incisors showing their left-right asymmetry and a heart-shaped incisal portion of the right crown. Scale in millimeters.

significant because of their timing, as well as their potential association with certain diseases. One such disease is congenital syphilis (Jacobi *et al*., 1992; Hillson *et al*., 1998). Congenital syphilis is not always detected at birth, as many of its clinical signs develop later (Mansilla and Pijoan, 1995), or, as in the case of the dentition, are not revealed until emergence (Hillson *et al*., 1998). Generally, skeletal markers such as bossing of the frontal bone, deformation of the nasal area, and inflammation of the tibia, known as sabre shin (Mansilla and Pijoan, 1995; Hillson *et al*., 1998; Ortner, 2003), are used to identify congenital syphilis in archaeological collections. However, dental defects such as Hutchinson's incisors, extreme linear enamel hypoplastic defects, transverse pitting in the enamel, Moon's molars, and mulberry molars also are considered symptomatic of the disease (Jacobi *et al*., 1992; Hillson *et al*., 1998; Ortner, 2003). In archaeological collections, dental stigmata are valuable for diagnosing congenital

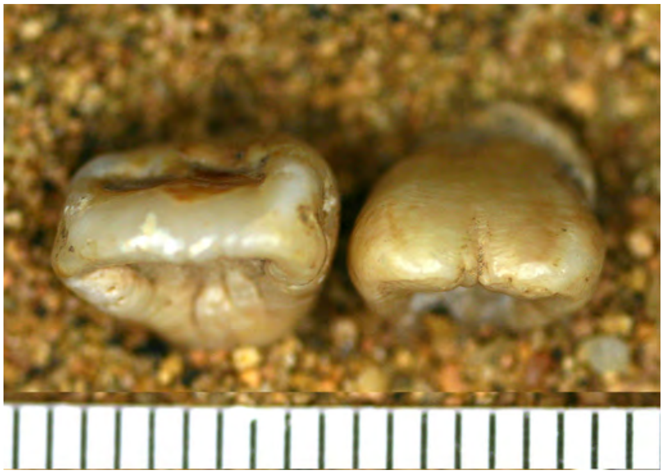

Fig. 3. Occlusal view of the central maxillary incisors showing a patchy hypoplastic defect (labial of right central) and a heart-shaped incisal portion of the crown (left central incisor). Scale in millimeters.

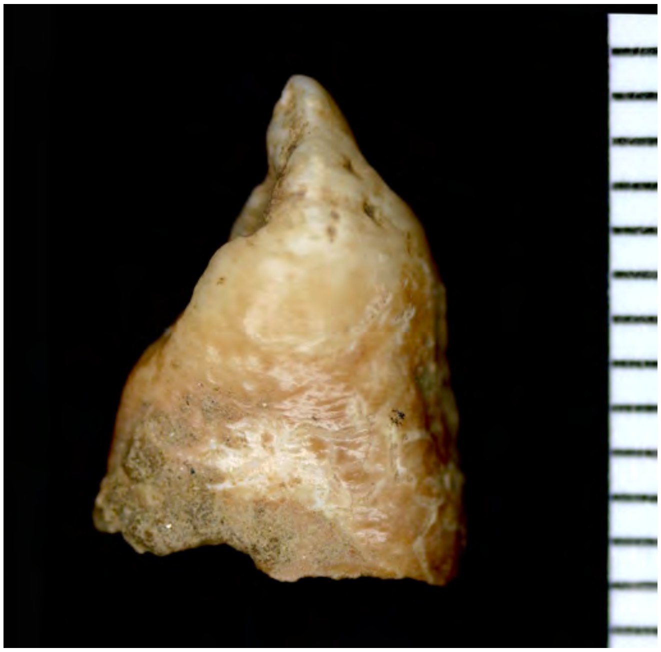

Fig. 4. Lateral view of the left maxillary canine showing the occlusal crown reduction due to extended hypoplastic defect. Scale in millimeters.

Fig. 5. Labial view of left maxillary canine showing occlusal crown reduction due to hypoplastic defects. Scale in millimeters.

syphilis because enamel does not remodel (as opposed to bone), and because enamel preserves well. A review of the literature, including case studies from historical, ancient, New World, and Old World groups, reveals a two-tier pattern of developmental defects resulting in the described dental stigmata. The first tier, or Level I defect pattern is a result of the genetic timing of tooth development; the second tier, or Level II defects, is an outcome of the environmental expression or, possibly, host response of particular stigmata.

Hillson and colleagues (1998:30) succinctly summarize the four most prominently known changes to the permanent dentition associated with congenital syphilis. Here they are represented by examples in form from the present case study. Note that the Level I conditions follow an identifiable pattern both in cases of known syphilis and archaeological specimens, with slight variation in form for the Level II conditions in reference to the presentation of morphology.

Fig. 6. Occlusal view of the maxillary teeth, showing the change in tooth shape of the central maxillary incisors, and the left maxillary canine. From the left, the teeth are the specimen’s right first premolar, right central incisor, left central incisor, left canine, and left first premolar.

1. “Hutchinson’s incisors primarily seen in permanent upper first incisors, but sometimes also in some permanent lower central and lateral incisors (never in permanent upper lateral incisors or canines). Showing a shortened incisal edge, with the mesial

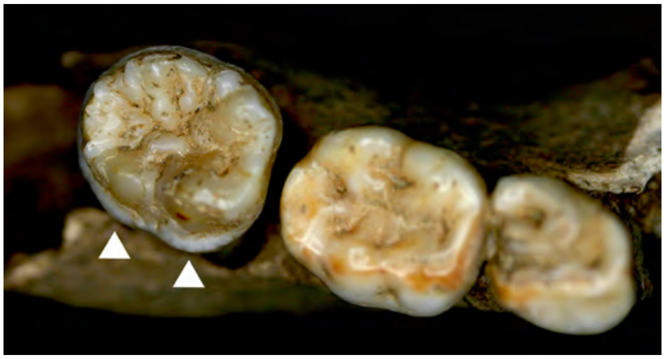

Fig. 7. Occlusal view permanent lower right first molar with reduced irregular cusps and a circumferential plane-like defect (arrows).

Fig. 8. Distal view of permanent lower right first molar showing circumferential plane-like defect with reduced crown size on coronal portion of the crown.

Fig. 9. Occlusal view of permanent right maxillary first molar (bottom) with reduced, irregular cusp and plane-like enamel defect.

and distal crown sides bulging out below it, and marked by a notch of variable shape" (Figs. 1-3).
2. "Permanent upper or lower canines with a sharp groove-like hypoplastic defect around the tip of their single" cusp (Figs. 4-6).
3. "Moon's molars, or bud molars. Only affecting upper and lower permanent first molars. All cusps are abnormally closely spaced, giving a narrow occlusal area relative to the bulge of the crown sides" (Figs. 7-8).
4. "Fournier molars, or more commonly mulberry molars. Also only affecting permanent first molars. Showing a marked plane-form hypoplastic defect, cutting sharply into the bases of all the cusps" (Figs. 9-13). The age range for crown defect for the individual presented here is birth to 1.5 years (Goodman and Rose, 1990) to 1.9 years (Reid and Dean, 2006).

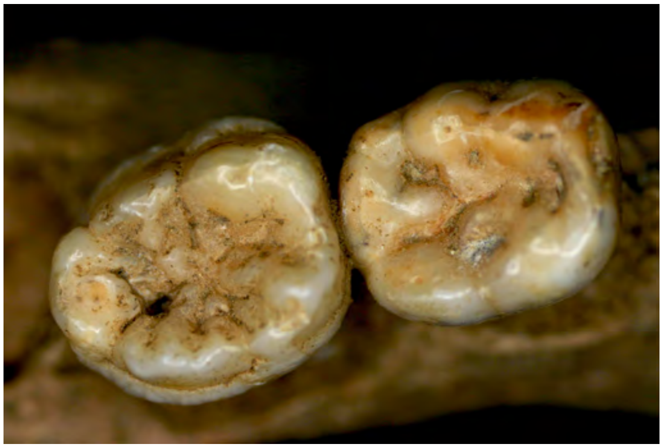

Fig. 11. Occlusal view of permanent left mandibular first molar (left) with circumferential plane-like defect.

Fig. 10. Interrupted circumferential plane-like defect on the first permanent molar (lingual view).

CASE STUDY BURIAL 10 – INDIVIDUAL 11

Archaeological Context

The presence of these dental stigmata in a juvenile buried at the Pre-columbian site of Yugüe in the Mexican state of Oaxaca are discussed. Occupied from the Middle Formative Period (700 – 400 BCE) until the late Terminal

Fig. 12. Interrupted circumferential plane-like defect on the first permanent molar (buccal view; mesial is to the right of the photograph).

Formative Period (CE 100 – 250), Yugüe is a 9.75 hectare site located on the floodplain of the lower Río Verde Valley on Oaxaca's western Pacific coast. The site was reoccupied in the Late Post-classic Period (CE 1200 – 1522) and persists as a small hamlet today. Historic and modern construction at the site has had a detrimental effect on buried human remains from the site, as discussed below. The core of Formative Period Yugüe was a 10 m high monumental earthen platform, first constructed around 150 BCE, that supported domestic and ceremonial architecture (Barber, 2005; Joyce, 1999). The summit of the platform was used for community ceremonial practices, including temple construction, burial, caching, and feasting (Barber, 2005). Today, a modern chapel sits atop the platform.

Burial 10 Individual 11 (B10-I11), the focus of this report, was part of a temporally and spatially distinct cemetery dating to the late Terminal Formative (Fig. 14). The cemetery contained at least 44 individuals densely-packed into an area of less than 7 m^2. Only three individuals were fully articulated; the rest had been disturbed by the internment of later burials, and some may have been secondary burials. B10-I11 is among those that had been disturbed by later burials. The lower half of the individual's skeleton was either removed or displaced by the later internment of at least two individuals. Individuals' ages within the cemetery ranged from neonate to elderly adult, with both males and females represented. In general, adults were buried in an extended position, placed on their right sides, with their heads to the west. Juveniles were placed perpendicular to the adults, lying on their left sides, with their heads to the south. There were some exceptions to this pattern, particularly among individuals who had been severely disturbed by subsequent internments (Mayes and Barber, 2008). The burial fill contained a number of offerings, particularly miniature ceramic vessels and potsherds, most of which could not be directly associated with a particular individual. In a few cases, associated artifacts did indicate that certain individuals were of higher social status than others in the cemetery (Barber, 2005; Mayes and Barber 2008). B10-I11 is one such case, as the individual was buried holding a long strand of green and white stone beads in the right hand. The presence of this socially valuable item has led investigators to suggest that B10-I11 was of high status (Barber, 2005).

Burial Description

An inventory of remains revealed that the vault and lateral portions of the skull are present. However, the face is crushed with elements identified only as being bone, not allowing for any description of morphology or identification of pathological changes. The frontal, parietal, occipital, temporal, and zygomatic bones are present, with the left sides in fairly good condition, and the right sides crushed and fragmented. There is a partial left portion of the sphenoid, but with the right side missing. Both the maxillae are fragmented, and the nasal and palatine bones are absent. The mandible is present but fragmentary. The lower limbs are missing, but the upper body is represented by the fragmented remains of the distal left humerus, a partial diaphysis and distal epiphysis of the right humerus, a damaged left radius, a portion of the right radial diaphysis, a damaged left ulna, and a portion of the diaphysis of the right ulna. Radiographic analysis was unavailable.

The portion of the skeleton in greatest abundance, and with the best preservation, is the dentition. Both permanent and deciduous teeth are present (Tables 1 and 2).

The taphonomy is substantial and underscores the paucity of information concerning certain skeletal elements that are present, with destruction to several surfaces in some cases, and the adherence of bone fragments and soil on others. This pattern is found in all available elements, including the roots and crowns of teeth. The skull has postmortem plastic distortion, with a slow crushing effect having taken place over the millennia. The practice of burying individuals on their sides resulted in severe damage to crania and innominates in this skeletal series. In B10-I11, the result is identifiable vault and lateral bones, with a complete loss of identifiable elements in the face, particularly around the nasal aperture. In addition, high clay and sand content caused the burial fill to behave almost like cement, with

TABLE 1. Inventory of deciduous dentition by root and crown development[1]

Arcade	dm2	dm1	dc	di2	di1
			Right Side		
Upper	PUN	PUN	PB	PUN	Ac
Lower	PUN	Ac	PUN	Ac	PUN
			Left Side		
Upper	PUN	PUN	PUN	PUN	Ac
Lower	PUN		Ac	PUN	PUN

[1] PUN stands for present but unobservable; PB stands for present but broken; Ac stands for apex complete.

Fig. 13. Distal view, showing the interrupted circumferential plane-like defect on the permanent left maxillary first molar.

a thick crust adhering to the surface of many bones, obliterating any surface changes, and adding to further deterioration of small bones. The material with the best preservation in this collection is the teeth, having gained some protection within the mandible. The taphonomic damage did facilitate determination of the specimen's age: the fragmentary condition of the alveolar bone and loose teeth allowed for the observation of crown and root development of erupting and un-erupted dentition (Figs. 15-18). This was useful given that radiographic analysis of the skeleton was not possible.

Burial 10 Individual 11 represents the remains of a child, age 5-6 years at the time of death, with severe physiological stress markings on his or her dentition. Many of the pathological changes in the teeth mirror those observed in documented cases of congenital syphilis (Figs. 1-13).

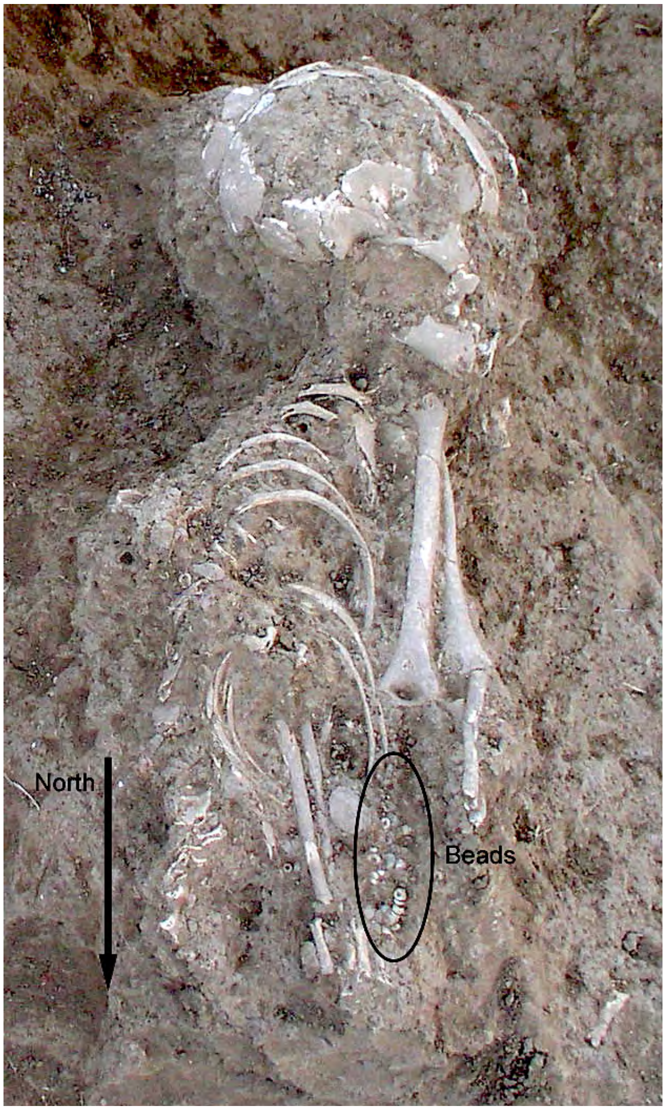

Fig. 14. View of the postmortem breakage that enabled observation of the unerupted dentition for use in dental aging of the specimen. The body was positioned on its left side. This seems to be an extended burial, but the remains of the pelvis and legs are lost.

*TABLE 2. Inventory of permanent dentition by root and crown development**

Arcade	M3	M2	M1	P2	P1	C	I2	I1
				Right Side				
Upper			R1/2	Crc	Crc			R1/4
Lower			R3.4			Ccr	R1/4	
				Left Side				
Upper	Cr3/4		PUN	PUN	Crc	Ri		R1/4
Lower			PUN				PUN	PUN

*PUN stands for present but unobservable, Cr3/4 stands for crown ¾ complete, Crc stands for crown complete, Ri stands for initial root formation, R1/4 root stands for root ¼ complete.

Fig. 15. B10-I11, view of the distal aspect of the maxillary right quadrant. The postmortem breakage of the alveolus exposes the second premolar so it can be used for dental aging.

Deciduous dentition

The deciduous dentition of this individual is essentially complete, with 19 of the 20 teeth present. There is extensive lytic invasion of the teeth from dental caries. Three out of the seven carious lesions caused decay of over half the tooth surface (URdc, URdi1, ULdm1), and one of these resulted in destruction of the crown (URdc). The other four lesions are not as severe, contributing to less than half of the affected surfaces destroyed (URdm2, URdm1, URdi2, LRdm2). Caries are primarily located on the interproximal surfaces, as well as one on the labial surface. The labial surfaces of the maxillary lateral incisors each have what can be described as wider-than-a-pit hypoplastic defect. On these teeth, the enamel appears to have an eroded or patchy appearance, with dark staining around the margins of the defect. Closer examination using magnification revealed abnormal enamel formation, not labial wear or taphonomic change (Fig. 19).

Fig. 16. B10-I11, left lateral view of skull showing taphonomic changes.

Fig. 17. B10-I11, right lateral view of skull showing taphonomic changes.

Permanent dentition

The developing permanent dentition exhibits extensive pathology which, unlike the deciduous teeth, is not generalized in nature. There are severe hypoplastic patches, or furrows, present on the labial surfaces of the upper right incisor and both lower central incisors. The defects are approximately 2 mm by 1 mm on average (Figs. 1, 20, 21). These defects are irregular. The central maxillary incisor is affected starting from the incisal edge, making the individual around one year old at the time of biological stress (Reid and Dean, 2006), followed by a slight recovery at one point, and then continuing until approximately two years old. The defect on the right mandibular central incisor began at around one year of age, with normal enamel formation resuming approximately 6 months later (using Reid and Dean, 2006). The maxillary incisors are symmetrical relevant to being developmentally affected, with the right incisor having two hypoplastic patches and a plane-like hypoplastic defect giving a cinched appearance, and the left having an unusual heart-shaped form that is an exaggeration of the normal scalloped shape (see Figs. 1-3). The left maxillary canine has a plane-like hypoplastic defect circumferentially near the occlusal surface, giving the cusp both a reduced and very pointed appearance (occurring between 1.4-2.0 years of age). This fang-like morphology is described in Jacobi *et al*. (1992) as resulting from cuspal hypoplastic lesions, and often present in cases of congenital syphilis (Fig. 6).

All four permanent first molars are present, and all exhibit a similar defect in form (Figs. 9-13). The occlusal third of the crown is reduced circumferentially from the rest. The base of the crown is wider than coronally, as the occlusal surface is markedly undersize. The difference between this section and the remainder of the crown creates a distinct ridge, which can also be described as a plane-like hypoplastic defect. The occlusal surface appears as a mass of randomly placed globules rather than defined cusps (Figs. 7-8). There is no defect apparent between the plane-like developmental defect and the cemento-enamel junction, indicating that the severe stress occurred very early in life and affected cusp formation from its inception, with relief at around one to one-and-a-half years. In comparison to the permanent second molar, the first molars are reduced in overall size, an additional symptom of the disease (Mansilla and Pijoan, 1995). All of these features are present in descriptions of congenital syphilis (Steinbock, 1976; Hillson *et al*., 1998).

DISCUSSION

Given the ongoing debate concerning the origins and antiquity of syphilis, it is important to rule out what the changes in the dentition do not reflect. There are several reasons why the dental defects described here are best interpreted as evidence for congenital syphilis rather than other forms of treponematosis. Congenital yaws, for instance, has been suggested as a cause of syphilis-like symptoms (Ortner, 2003). However, dental stigmata described here require the mother to be in the secondary stage of the disease when pregnant, whereas other forms of treponematosis (like yaws) do not produce symptoms until after birth. In terms of other diseases and stresses, children with congenital tuberculosis die shortly after birth (Lewis, 2007), leaving no time for developmental changes to the permanent dentition. A deficiency in vitamin C (scurvy) affects the dentition indirectly, and then only the roots (Lewis, 2007). With regard to non-specific indicators of stress, such as hypoplastic defects, it is clear that a host of diseases can and do cause disruptions and changes in dental formation, but, in these cases, all teeth can be affected. In the case of B10-I11, very specific teeth were malformed at very specific points during development.

As mentioned, a review of the literature on congenital syphilis suggests two levels of patterning in dental defects. Level I defects are genetically tied to the age of development for the involved dentition, and the range of affected teeth within a dental field is restricted to the first incisor, the canine, and the first molar. Level II defects refer to differences in the range of form of the affected teeth, and their variation in environmental expression or host response (which may encompass a differential population response). This range in acquired defects may be particularly important in discerning differences between Old World and New World manifestations of congenital syphilis, or as evidence of multiple syndromes. It should be noted that skeletal manifestations of treponematosis also vary in form and severity. While skeletal changes due to treponematosis have been documented in similar regions of the anatomy or skeletal elements, the degree of involvement differs with each syndrome (Steinbock, 1976). It cannot be ruled out that slight variations in affected dentition may occur as well. For instance, Hutchinson and Richman (2006) discuss permanent first molars from two separate suspected syphilitic New World individuals. “However, neither could be defined as a good example of a Moon’s molar” (Hutchinson and Richman, 2006:551). It should be noted, however, that their description of this tooth, and others, fit the Level I rules of affected teeth; the tooth they present (their Fig. 11:555) does have a severe plane-like defect, with a reduction of cusp size from the occlusal tip. The tooth appears to be a slight variation in form of previously described Moon’s molars.

The literature varies as to the frequency of dental stigmata in cases of congenital syphilis. The range of 30-45% (Erdal, 2006; Steinbock 1976; Hillson *et al*., 1998) can be attributed to discussions on specific characteristics in documented cases and archaeological collections. While these frequencies differ, several points are clear. First, dental stigmata are not exhibited 100% of the time, even in documented historic cases. Using Putkonen’s figures of Hutchinson’s incisors being present in 45% of the cases of congenital syphilis, then it should be equally clear that in 55% of the cases, they are not. Another facet of the disease is that individuals may not exhibit any of the dental defects, and only show changes in the cranial and post-cranial bones.

When dental defects do exist, depending on when the affected individual died, there is a range of anomalies that do follow a particular pattern. Variation in the morphology of the teeth may be one of the discerning differences between Old World and New World

Fig. 18. B10-I11, right lateral view of skull showing taphonomic changes.

manifestations. Therefore, knowing and recognizing variation in symptomology of this disease in antiquity can be valuable. It may also be one of the keys to understanding and identifying various forms of this disease and its dispersion globally.

Hutchinson's incisors affect the permanent teeth, and the feature is primarily seen in the maxillary central and, occasionally, the mandibular incisors. Steinbock notes a wide range of expression in this trait, from the variation described above to "only a depression on the anterior surface of the tooth immediately above the cutting edge, and in some both of these alterations are present" (1976:108). He also notes that it is not always bilateral, and that, in some cases, it may not exist at all. Hutchinson and Richman (2006) describe a child with "malformed enamel sleeves," which they note do not look like Hutchinson's incisors as typically described. However, these two teeth do look very similar to those described by Steinbock (1976). The right central incisor of B10-I11 also has a malformation that is similar in form. In Steinbock's (1976) examples of dental stigmata for congenital syphilis, the lateral maxillary incisors also are affected. This "notch in the incisal margin and rounding of the incisal angle" with a "fissured" labial surface (see Fig. 40 in Steinbock 1976:107) describes, and resembles, the permanent left central maxillary incisor of B10-I11 (Figs. 1-3).

Permanent canines exhibit occlusal hypoplastic defects (Jacobi *et al.*, 1992), and the first permanent molars are also affected by congenital syphilis. A degree of overall consistency is maintained that aids in identification in expected dental stigmata. Descriptive summaries of the defects are also useful in comparing data. Jacobi and colleagues (1992) provide a summary table of descriptions of characteristics attributed to congenital syphilis. The main identifying feature of mulberry, or bud, molars is a "marked defect of enamel hypoplasia, running around the base of all cusps. It corresponds to what has been described as a plane-form hypoplastic defect" (Hillson *et al.*, 1998:30). Where the cusps of affected teeth are deformed, having "several small knobs representing atrophic cusps" (Steinbock 1976: 108). In addition to Hutchinson's incisors, both Moon's and mulberry molars are expressions of congenital syphilis.

Fig. 19. B10-I11, labial view of the maxillary left lateral incisor with defective enamel in the middle third of the crown. The canine (on the right in the photograph) shows scattered enamel pitting.

There are a number of similarities between the teeth from the current study, and that of Hillson and colleagues (1998). Of note are the narrowed occlusal surface, the disorganization of the cusps, and the plane-like hypoplastic defect visible around the circumference. Any combination of these dental defects can be considered expressions of the disease, which is why the degree of certainty in diagnosing congenital syphilis in archaeological specimens can be low, at times. Additionally, the degree to which an individual was affected by the disease, and the observed physical changes present at the time of death, may also affect diagnosis of archaeological specimens.

Fig. 20. Deciduous left maxillary lateral incisor with a lingual hypoplastic defect in the middle third of the crown.

Fig. 21. Permanent mandibular central incisors with furrowed defect in the middle third of the crown; labial view. Distal is to the left of the photograph; scale in millimeters.

Skeletal investigations of pre-contact burials from Gabriola Island, Canada (Pacific Northwest) identified several individuals, adult and sub-adult, with skeletal changes that appear to be due to syphilis. Curtin (2005) describes a disassociated juvenile mandible, the teeth of whom match the current description of syphilitic stigmata, and which parallel case study (B10-I11) presented here, both in terms of the teeth affected and the degree of malformation.

> The affected teeth are the two permanent mandibular first molars and the developing right permanent mandibular canine. The molars are severely hypoplastic, with rounded bulbous cusp tips constricted at their base by a deep, irregularly pitted hypoplastic groove that encircles the crown. The cusp tips appear crowded together toward the center of the occlusal surface, which itself features many small, irregular enamel globules, producing the 'mulberry' appearance characteristic of Fournier molars [Curtin, 2005:315].

Additionally, the canines are described as having "circumferential" and "furrow-shaped defects "remarkably similar to one illustrated in Hutchinson's 1887 treatise on syphilis" (Curtin, 2005:315). The described pattern of the canine is a slight variation from Hillson and colleagues' (1998) descriptions, but it mirrors that of B10-I11. Similarly, the authors note that the Gabriola Island individual has a deciduous dentition with marked hypoplastic defects.

In a skeletal collection from Barbados, Jacobi and colleagues (1992) have described the impact that congenital syphilis had on nineteenth century African-American slaves. Three individuals, all adolescents or young adults, had Hutchinson's incisors and Moon's molars. The authors acknowledge that many of the children who died from the disease might not have developed the characteristic dental deformations. They assert that the infant mortality rate due to congenital syphilis was probably quite a bit higher than evidenced by the skeletons themselves. Not all infected infants will acquire the dental stigmata, but most will have changes in some skeletal units. Those who survived to childhood would recover, leaving little evidence of these changes to their long bones during infancy (Steinbock, 1976). This is important, for even if the lower limbs of individual B10-I11 had not been missing, given the age of the individual at death and depending on the severity of the infection, no pathological change may have been evident.

Hillson and colleagues (1998) do not consider the deciduous dentition to be a part of the normal stigmata, but other sources have noted severe developmental disruptions of the milk teeth (Steinbock, 1976; Ortner, 2003; Curtin, 2005; Hutchinson and Richman, 2006). Defects on the deciduous dentition, while not normally considered part of the suite of changes, certainly speak to issues with the mother's health during fetal development. Given that congenital syphilis is contracted transplacentally (Lewis, 2007), it is expected that other negative effects on the growing fetus can be documented, so the hypoplastic "patch" identified on the central maxillary deciduous incisor of B10-I11, and additional hypoplastic pitting, are not surprising.

CONCLUSION

Differential diagnosis of congenital syphilis from skeletal remains should consider all bony and dental manifestations. The postmortem damage to this individual is considerable, with the face splintered, the skull crushed, and the lower extremities absent. Preservation and taphonomy prevented the assessment of the skeletal markers of congenital syphilis in this case. However, the pattern of dental defects that developed is significant and is consistent with previously described changes due to congenital syphilis.

Not every manifestation of treponematosis is completely understood. It is for this reason that all possible cases should be introduced, particularly when what is observed follows a generally recognizable pattern, though with slight morphological variation. Such variations are already documented in the literature (Hillson *et al*. 1998), meaning that case studies, even from unexpected locales, cannot be ignored. Possibly, expression of some malformations varies by population (genetic and physiological) and/or the environmental framework, but which teeth are affected by this disease process, does not vary. If there are evolutionary differences in form for this disease based on geographic location, or on differing bacteria, they do not appear to affect the Level I rules of dental field pattern. There are, nonetheless, certain variations of Level II-expression of malformations. A better understanding of these differences and their range of expression may aid in identifying New World and Old World syndromes in antiquity. The data presented here is suggestive of a congenital form of treponematosis in the New World, possibly congenital syphilis.

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Discriminatory Effectiveness of Crown Indexes—Tests Between American Blacks and Whites

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ABSTRACT Tooth crown shapes differ among human groups because the sizes and shapes of the constituent crown components differ. It was of interest to us whether there is patterned variation in crown indexes between sexes or among ethnic groups. The crown index—buccolingual width as a function of mesiodistal length—was analyzed here in terms of sex and race differences in a cohort of American black and white adolescents (n = 324) from the U.S. Mid-South. The mandibular canine is distinctive in exhibiting significant sexual dimorphism in crown shape, with females being broader in terms of mesiodistal length. Prior literature reports the crown indexes of several tooth types to be dimorphic, which does not occur here, showing that the extent of sexual dimorphism differs among groups. In contrast, we found that multiple crown indexes differ significantly between the samples of blacks and whites, with the largest differences in UC, UP1, and LM2. Of note, nature of the differences are tooth-specific, suggesting that divergence among groups at this microevolutionary level has shifted crown shapes along distinctive (rather than parallel) pathways. The optimum subset of crown indexes correctly allocates 67% of the specimens as to race; this percentage is not much better than chance, suggesting that crown indexes are of little forensic usefulness in discriminating among contemporary humans. *Dental Anthropology* 2009;22(3):85-92.

Crowns of teeth vary both in size and shape, and this is well documented by dental anthropologists who have detailed the variations in the morphologies of all tooth types (*e.g.*, Korenhof, 1960; Morris, 1965; Turner *et al*. 1991; Scott, 2008). In turn, differences in the number and size of cusps, cingular features, and other details of the crown influence tooth size (*e.g.*, Kondo and Townsend, 2006). Conversely, tooth size is statistically and developmentally associated with crown complexity (*e.g.*, Keene, 1968; Garn 1977).

Researchers have traditionally focused on the maximum mesiodistal (MD) and buccolingual (BL) diameters of teeth (Goose, 1963), though other dimensions may be at least as informative (Corruccini, 1979; Hillson *et al*., 2005). Aside from some Australian and Melanesian groups with very large tooth sizes, there are rather few obvious intergroup differences in crown dimensions, and this has dampened anthropologists' enthusiasm for collecting tooth size data (*e.g.*, Lasker and Lee, 1957; Moorrees, 1957). The disinterest in odontometrics has been compounded by the slow growth of analytic methods that are tractable and actually address anthropological questions (see, *e.g.*, Reyment *et al*., 1984; Hanihara and Ishida, 2005). One early thought was that, if tooth crown sizes don't vary much across populations, perhaps tooth shape would be informative (*e.g.*, Hrdlička, 1923; Nelson, 1938; Selmer-Olsen, 1949). Calculating shape indexes also extends logically from the numerous ratios calculated by anthropometrists, osteologists, and craniometrists that emphasize shape rather than size differences (*e.g.*, Wilder, 1920; Martin, 1928), though Albrecht *et al.* (1993) provide some cautionary notes against the uncritical use of ratios.

The crown index (BL/MD times 100) has long been used as a measure of crown shape. Selma Thomsen (1955, p 4) states that, "This index was introduced by Retzius, a Swedish anatomist," but she does not supply a citation. Anders Retzius (*b*. 1796 – *d*. 1860) is better known in dental circles as the person who described histological features of the enamel: "In ground section the enamel is marked by brown bands called the bands, striae, or incremental lines of Retzius" (Bhaskar, 1962, p 103). Application of the crown index evidently caught on quickly; de Terra reports it (*Zahnbogenindex*) without explanation (de Terra, 1905). The crown index expresses crown width (BL) as a function of length (MD), so a large index reflects a broad-short crown form, while a small index indicates a narrow-long form. The index is only an approximate measure of shape because tooth crowns are not essentially rectangular in form.

The purpose of the present study is to explore the utility of using crown indexes of the permanent teeth to distinguish between males and females and, secondly,

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to test for differences between American blacks and whites. These differences may suggest intra-specific ('racial') differences in modal crown development. So too, the data may be of forensic use in estimating the race and/or sex of an unknown specimen (*e.g.*, Ditch and Rose, 1972).

MATERIALS AND METHODS

The crown dimensions measured from full-mouth dental cases were obtained from 324 adolescents in whom all 28 permanent teeth (omitting third molars) were fully erupted. Teeth were intact (not affected by caries, trauma, or casting defects). Teeth from just one side of the arch were measured because of the essential symmetry of the dentition. Electronic-readout sliding calipers were used (precise to 0.005 mm), with beaks machined to fit well into the embrasures, and the measurement method described by Seipel (1946) was followed.

Subjects had been patients in the Department of Orthodontics at the College of Dentistry, Memphis, Tennessee, and sample sizes were 52 black males, 74 black females, 94 white males, and 104 white females. Cases were phenotypically normal, and cases with congenitally absent teeth (ignoring third molars) were not included (Garn and Lewis, 1970; Kirveskari *et al.*, 1978).

The crown index of each of the 14 tooth types was calculated using a spreadsheet program, and two-way factorial analysis of variance (Winer *et al.*, 1991) was used to concurrently test for race and sex differences. Stepwise discriminant functions analysis (Cooley and Lohnes, 1971) then was used to find optimal subsets of the variables that maximally separate the sexes (or the races). Statistics were performed using JMP (SAS Institute, Cary, NC) and SPSS (SPSS Inc., Chicago, IL).

RESULTS

Univariate analysis

Descriptive statistics are listed in Table 1, where it is evident that the majority of mean crown indexes are above 100 simply because BL breadths exceed MD lengths (Keith, 1916). The maxillary premolars have the highest indexes, on the order of 130 for P1 and 140 for P2. At the other end of the spectrum, maxillary incisors (I1, I2) have means appreciably below 100 because their crowns are wide but narrow faciolingually. The lower molars also have small mean indexes, at about 94 (M1) and 97 (M2), probably because the talonid, which extends crown length mesiodistally, is well developed on these teeth.

Statistical tests for sex differences (Table 2) are interesting because only one of the 14 F-ratios achieved significance ($P < 0.05$), but, of note, the significant sexual dimorphism (for the lower canine) is highly significant ($P < 0.0001$). In other words, while males tend to have larger crown dimensions than females (*e.g.*, Garn *et al.*, 1967; Potter, 1972), the length-to-width ratios tend to be the same in the two sexes for most tooth types. The exception is that the crown index for LC is appreciably higher in females than males (Fig. 1), and inspection of the sizes shows that the sex difference is principally due to the much greater MD length of LC in males (whereas the BL sex difference is trivial). This strong statistical difference suggests that LC crown shape may be useful for sex discrimination.

Half of the crown indexes (7/14) are significantly different between the black and white samples (Table

TABLE 1. Descriptive statistics for the crown index, by race and sex

Tooth Type	Black Females $\bar{x}$	Black Females sd	Black Males $\bar{x}$	Black Males sd	White Females $\bar{x}$	White Females sd	White Males $\bar{x}$	White Males sd
				Maxilla				
I1	81.92	6.42	81.07	6.78	81.37	8.76	80.55	7.07
I2	93.75	8.94	93.19	9.79	90.75	10.68	91.31	11.90
C	106.35	7.18	104.12	6.81	102.44	9.08	102.93	8.77
P1	130.51	5.75	129.52	6.85	132.61	7.41	133.35	8.01
P2	141.00	8.54	142.68	8.20	139.84	8.52	141.66	9.36
M1	109.50	5.72	109.39	6.17	110.58	5.26	111.26	5.56
M2	107.82	6.80	107.53	6.50	109.51	8.94	108.33	6.33
				Mandible				
I1	105.97	8.20	103.42	9.60	105.65	9.53	107.01	9.52
I2	102.87	7.20	101.52	9.64	100.89	8.51	99.38	9.37
C	104.37	6.63	99.83	9.27	104.17	9.15	100.21	10.00
P1	108.94	6.51	109.26	8.23	109.65	7.73	110.48	7.05
P2	118.40	8.25	120.30	9.07	117.70	7.94	118.72	8.16
M1	93.52	4.71	92.29	4.38	94.09	4.70	94.26	5.02
M2	95.90	6.48	93.03	6.19	97.05	5.87	98.60	5.89

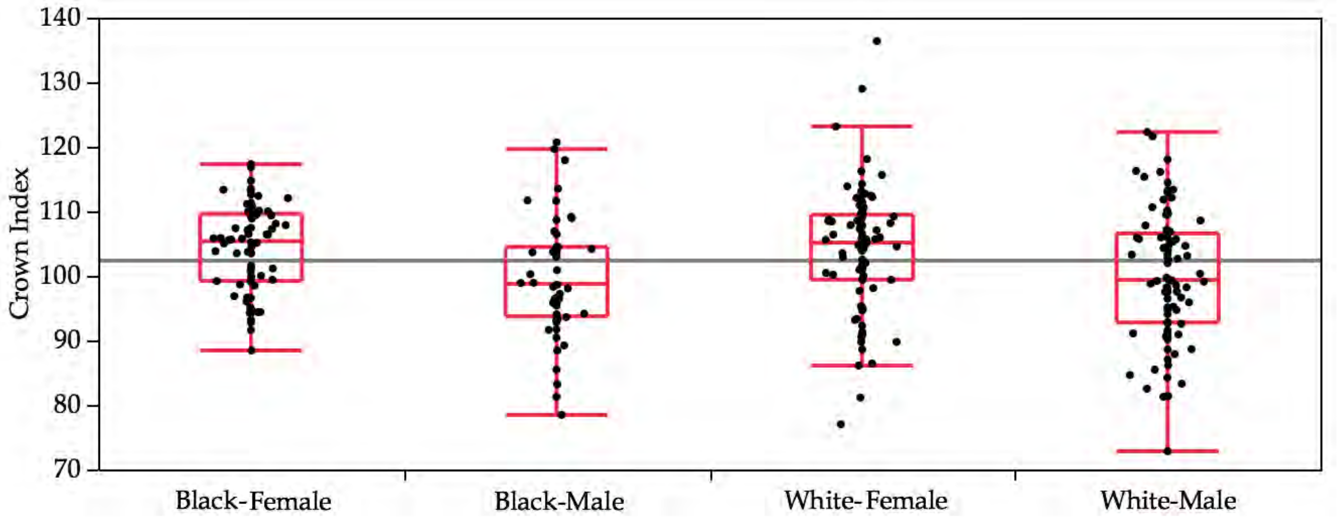

Fig. 1. Boxplots showing the distributions of the crown index for mandibular canine. Median indexes are higher in females than males in both the black and white samples.

2) when assessed univariately (alpha = 0.05). There is, however, a complexity as to which group has the larger crown index (Fig. 2). Inspecting the F-ratios, two teeth stand out as particularly different, namely maxillary P1 and mandibular M2. In both comparisons, the white sample has the larger crown index, indicating that these teeth are more broad-and-short in whites than blacks.

Multivariate analysis

We used stepwise discriminant functions analysis to identify the subsets of variables that are most predictive of sex and, separately, most predictive of race. Prior probabilities were set to be equal across groups.

As suggested by the univariate analysis (Table 2), only the crown index of LC is predictive of a subject's sex. When all 14 indexes are input into the discriminant algorithm (races combined), just LC is retained, and it correctly classified 62% of the cases as to sex using the jackknife ("leave-one-out") method. This percentage is better than chance, but is not as reliable as other skeletal and dental methods (*e.g.*, Buikstra and Ubelaker, 1994).

Using the 14 indexes to estimate race (either American black or white), the stepwise procedure retained 5 of the 14 variables (sexes combined). This is a fairly large number of variables, and it suggests that the crown indexes are not strongly intercorrelated (Garn *et al.*, 1967c). Correct allocation is 67% (jackknife)

TABLE 2. Results of factorial ANOVA tests for race and/or sex differences in crown indexes

Tooth Type	Race		Sex		Interaction	
	F Ratio	P Value	F Ratio	P Value	F Ratio	P Value
			Maxilla			
I1	0.38	0.5404	0.93	0.3348	0.00	0.9857
I2	3.99	0.0466	0.00	0.9966	0.21	0.6448
C	7.22	0.0076	0.84	0.3589	2.05	0.1532
P1	12.79	0.0004	0.02	0.8825	1.09	0.2963
P2	1.17	0.2794	3.03	0.0826	0.00	0.9458
M1	5.20	0.0232	0.20	0.6572	0.39	0.5345
M2	2.14	0.1441	0.75	0.3876	0.27	0.6059
			Mandible			
I1	2.34	0.1272	0.31	0.5756	3.35	0.0680
I2	4.22	0.0409	2.04	0.1546	0.01	0.9372
C	0.01	0.9317	17.07	<0.0001	0.08	0.7803
P1	1.26	0.2629	0.44	0.5093	0.09	0.7684
P2	1.43	0.2331	2.33	0.1282	0.21	0.6465
M1	5.35	0.0213	0.93	0.3352	1.62	0.2041
M2	17.21	<0.0001	0.67	0.4152	7.47	0.0067

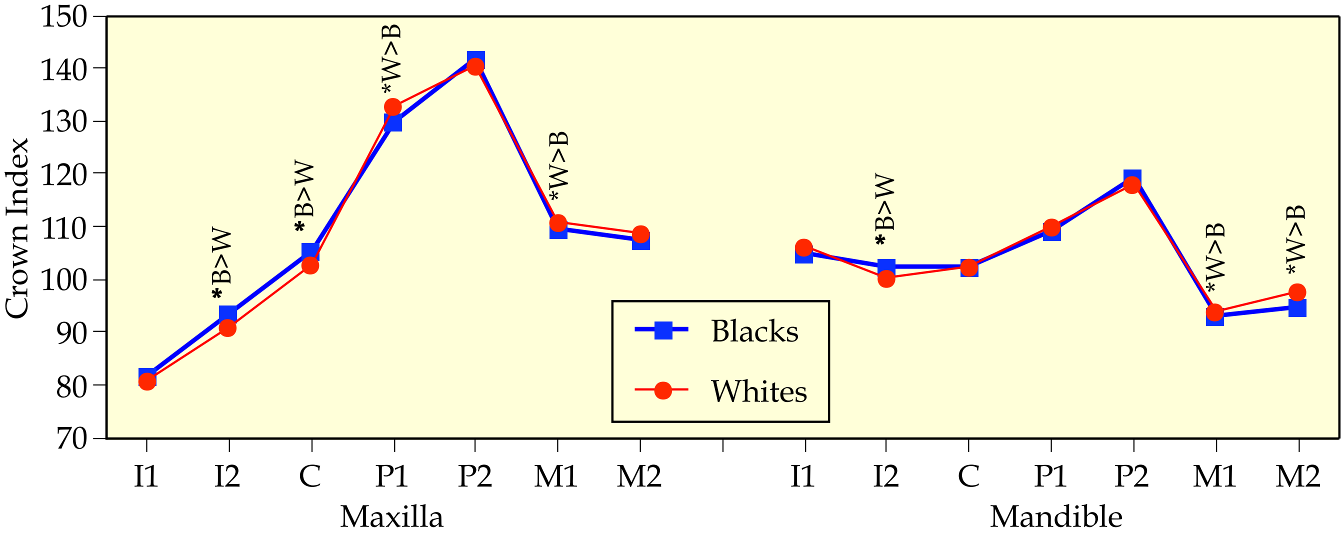

Fig 2. Plots of the mean crown index, by race and tooth type. Seven of the 14 black-white differences are significantly different as judged univariately. Blacks have larger indexes in the anterior region (incisors, canines) as denoted by the "B>W" code. Indexes in the buccal segment (premolars, molars), in contrast, are larger in the white sample ("W>B"). This mixture of differences among teeth can be interpreted as region-specific changes in crown shape over the microevolutionary time separating these groups.

using these five variables. These five variables do not contribute equally to the discrimination, and the structure matrix shows that UC and LM2 are most informative. Conversely, the crown indexes for UP2 and LP2 contribute little. Retaining just the three most useful variables gives this prediction equation:

$$\text{Race} = -11.856 - 0.080(\text{UC}) + 0.079(\text{UP1}) + 0.101(\text{LM2})$$

Correct allocation remains at 67% even with removal of the two least-informative variables. These values in the equation are the unstandardized coefficients, but their ranking is the same as when standardized: UC is the most predictive (*i.e.*, it has the strongest correlation with the canonical function), and blacks have a higher index (relatively broader-and-shorter UC) than whites. LM2, with a higher crown index in whites, also is informative. The third variable is UP1, and it also has a higher index in whites.

Values at the group centroids are 0.270 for whites and -0.461 for blacks. Substituting actual numbers for these three crown indexes into the equation above yields a number, where a positive value suggests the specimen is a white, and a negative value suggests the specimen is a black. A value near zero is indeterminate, and the farther the value is from zero the more likely it is that the race assignment is reliable (Campbell, 1984; Kieser and Goeneveld, 1989).

The canonical function shows that UC, UP1, and LM2 exhibit the best discrimination between blacks and whites when relying on tooth crown shape. Signs of the coefficients show that separation of these two races depends on a contrast between upper canines with a short-and-broad outline (characteristic of blacks) compared to short-and-broad UP1 and LM1 (characteristic of whites). This mix of crown shapes strengthens the view that crown morphologies have diverged independently among the tooth types over time (Harris and Harris, 2007).

DISCUSSION

The crown index is an approximation of true crown shape, and it provides a comparison of shape independent of size. In turn, the number and relative sizes of cusps—the component parts of the crown—affect crown shape. The number of cusps is determined by the number of secondary enamel knots (Jernvall *et al.*, 1994; Thesleff and Jernvall, 1997), though what controls knot formation is poorly understood. Spacing of secondary enamel knots and subsequent expansion among the cusps prior to the cessation of growth by bridging due to dentinogenesis controls cusp size and the cusps' spatial arrangement (*e.g.*, Butler, 1967), though again little is known about the developmental mechanisms (biochemical signaling) governing these growth processes (*e.g.*, Salazar-Ciudad, 2008; Salazar-Ciudad and Jernvall, 2002, 2004).

Physical anthropologists (as here) conventionally are limited in their analysis to the teeth themselves—the phenotypic end-products of ontogeny—so there is little to investigate about the formative processes.

Sexual dimorphism

Teeth tend to be larger in men than women, though the extent of sexual dimorphism is modest in humans compared to other species of the great apes (Swindler,

Fig. 3. Buccal view of a mandibular right M1 sectioned mesiodistally. The arrows mark the approximate heights of contour (defining maximum crown diameter), and it is evident that most of the "bulge" of the crown apical to the occlusal table is due to enamel thickness, but it also is contributed to by the convexity of the dentinoenamal junction that was formed by the inner enamel epithelium prior to mineralization. Diagram modified from Zeisz and Nuckolls (1949).

2002). The traditional argument is that sex hormones, notably testosterone, enhance mitotic activity to create larger teeth in males (Guatelli-Steinberg *et al.*, 2008). Interestingly, enamel formation (amelogenesis) does not account for sex differences in tooth size (Stroud *et al.*, 1994, 1998), though that had been a reasonable supposition (Moss, 1978). Instead, differences stem from greater dimensions of the inner enamel epithelium that are established prior to tooth mineralization (*e.g.*, Corliss, 1976; Avery, 1994). Larger size—and any shape differences—stems from growth of the inner enamel epithelium, and dentin formation progresses internally from this epithelial margin (Fig. 3). Greater pulp dimensions in males (Moore, 1989; Woods *et al.*, 1990) can be viewed as the volume created by the inner enamel epithelium that is not composed of dentine in the mature tooth.

Garn *et al.* (1967b) suggest that a sex difference in crown indexes follows logically from the observation that percent sexual dimorphism is greater in the BL than the MD axis of teeth. This was true for his sample of whites (Garn *et al.*, 1966) and it also is true for the present data (not shown), where percent sexual dimorphism is greater in the BL axis for 10 of the 14 tooth types. This does not, however, translate into sex differences in the crown index. Interestingly (Fig. 4), Garn's sample of whites (Yellow Springs, Ohio) possesses much greater sexual dimorphism across the crown indexes than the present sample of whites (Memphis, Tennessee). Fully half (7/14) of the tooth types achieved a significant sex difference in Garn's sample, while, as we emphasized earlier, only the lower canine had a significant sex difference in the present study. Lack of statistical significance is not due to Type II errors insofar as our sample sizes of whites are larger than Garn's. These inter-group differences may be influenced by technical issues, such as operator bias (Kieser *et al.*, 1990) or differences in instrumentation (Garn *et al.*, 1967a), but we favor the issue of regional differences in tooth size among "whites" across the United States—though virtually nothing is known about this.

The present data on crown indexes show that growth of the male and female teeth are essentially isometric—that males are (using this index) enlarged analogs of the female archetype. In other words, while males have metrically larger teeth (*e.g.*, Mijsberg, 1931; Garn *et al.*, 1964, 1967d), their length-width ratios are proportionately enlarged versions of females (Harris and Hicks, 1998), and there is the retention of the same gnomon

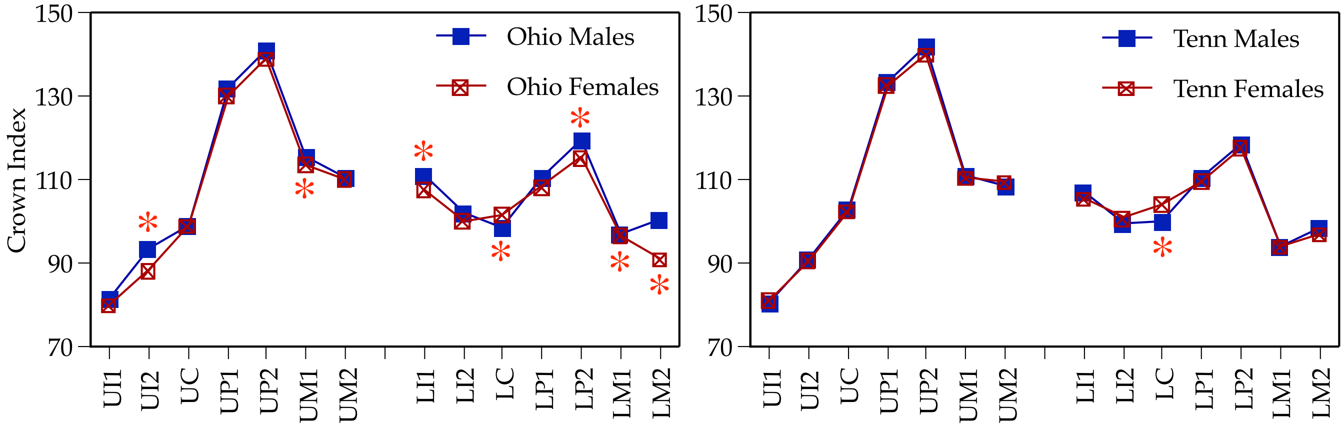

Fig. 4. Plots of the crown index for the 14 tooth types in (***left***) a sample of Ohio whites (Garn *et al.*, 1967a) and (***right***) the present sample of whites from Tennessee. Asterisks mark the 7 tooth types that Garn *et al.* reported as statistically significant, whereas just one of the 14 teeth was significantly dimorphic in the present study even though sample sizes are comparable.

(shape) with increased size (Thompson, 1948).

The one exception is the mandibular canine, where females have a distinctly higher crown index. While the MD and BL dimensions are smaller for females, their LC crowns are disproportionately shorter mesiodistally. That is, BL widths vary little between the sexes, and differences in MD lengths are about three times larger than the width difference, yielding a larger crown index in females.

Black-white differences

It has long been recognized that sub-Saharan blacks have large teeth, especially compared to rather small-toothed Europeans (*e.g.*, Topinard, 1886; de Terra, 1905), and more recent studies confirm this, including odontographies by Shaw (1931) and Jacobsen (1982). Likewise, early black-white comparative studies (*e.g.*, Hrdlička, 1923; Nelson, 1938; Selmer-Olsen, 1949) show that the dental differences are complex. Differences in the crown index are location-dependent rather than uniform across the tooth types. A crude measure of this is that, of the 7 significant differences (Fig. 2), three are due to higher indexes in blacks, while the other 4 are higher in whites.

The governing principle is that blacks tend to have disproportionately broad crowns (compared to MD lengths) in the anterior segment of the arches (incisors, canines)—so crown indexes are larger than for whites. Conversely, the white sample has disproportionately broader (and/or mesiodistally shorter) crowns in the buccal segment (premolars, molars). These differences in proportionality led Harris and Rathbun (1991) to label the dentitions of sub-Saharan Africans and their derivative groups as “front loaded” in the sense that a greater portion of their overall crown size is distributed among the anterior teeth. People of European extraction, in contrast, tend towards the opposite expression, where greater portions of their overall crown area are apportioned to the premolars and molars. Of course, these proportional differences are evaluated independently of the absolute sizes of the dentitions.

This complexity of differences in crown indexes should be useful in forensic studies of estimating the race of an unknown specimen (Ditch and Rose, 1972).

OVERVIEW

Tooth crown size and shape are necessarily interrelated, and the present study assesses a time-honored approximation of crown shape, namely the crown index. Samples of American blacks and whites were analyzed from the U.S. Mid-South.

- While human males typically have larger crown dimensions, most tooth types are not sexually dimorphic in these samples. The exception is the lower canine with a significantly higher crown index in females because of disproportionately short crown lengths.
- Several tooth types exhibit significantly different crown indexes between American blacks and whites, though the indexes are a mixture of higher and lower values.
- Three variables (UC, UP1, LM2)—but especially the higher crown index of UC in blacks—are useful for discriminating between these samples of American blacks and whites.

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Brief Communication: A Unique Dental Resource: The Odontological Collection at the Royal College of Surgeons of England

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The Royal College of Surgeons of England.

ABSTRACT This report describes the development of a searchable electronic data base of the dentally-relevant holdings of the Royal College of Surgons of England. This odontological collection is accessible through the world wide web at http://surgicat.rcseng.ac.uk/. Highlights of a few of the holdings are described here along with information for accessing the collection. *Dental Anthropology* 2009;22(3):93-95.

The Odontological Collection at the Royal College of Surgeons of England is a vast research source consisting of a wide range of cranial and dental material. Over 10,000 human and animal specimens are contained in the collection, all of which can be searched online and made available to researchers visiting the College by prior appointment. Two themes are covered by the collection: (a) specimens displaying pathologies of the teeth and jaws and (b) material illustrative of dental development and growth. Specimens displaying pathological conditions include a range of congenital, metabolic, and infectious diseases in addition to examples of maxillofacial trauma. Developmental material includes human specimens from foetus to adult and a range of animal material that has the potential for extensive comparative anatomical studies. The diversity and ready availability of the Odontological Collection make it useful to researchers from a range of disciplines. This article presents a brief history to the collection, reviews its contents, hopefully, discloses its potential for academic investigation. Details also are provided as to how to locate and navigate around the online catalogue 'Surgicat' to perform general or specific searches.

The origin of the collection dates back to the 1850s when the Odontological Society of Great Britain was founded. Four years later the College of Dentists was absorbed into this Society, leading to the creation of a museum. In the early 1900s the Odontological Society was incorporated into the newly-formed Royal Society of Medicine as its Odontological Section. The Society's collection was placed on loan to the Royal College of Surgeons in 1909, and in 1943 the collection was transferred to the College on a permanent basis. Transference was a goodwill gesture towards reconstitution of the museum, which was grievously damaged by bombing in 1941. Dental material from several sources has been collated throughout the last two

Fig. 1. The maxillae and mandible of a child aged 7 years 3 months, showing the developing dentition. The outer surface of the alveolar bone has been removed to expose the stages of development and eruption of each tooth type. From the collection of Sir John Tomes.

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Fig. 2. Five molar teeth from different individuals showing enamel pearls in the region of the root furcation.

centuries, the majority having originated from eminent surgeons, dentists, and zoologists who made regular donations to this ever increasing research source.

Significant figures in the field of dentistry made regular contributions to the collection, often of personally prepared skeletal material that exposes root formation or developing permanent teeth (Fig. 1). Such individuals include the seminal dentists Sir John Tomes, his son Charles, and Sir Edwin Saunders. Some specimens are of particular historical interest, such as the short twine necklace of 38 human teeth brought back from the Congo River by the explorer Henry Morton Stanley, and the selection of teeth retrieved from soldiers in 1815 who perished during the battle of Waterloo. The most recent contribution was Sir Winston Churchill's dentures, donated in 2000.

Some of the human material is archaeological in acquisition. Those obtained through excavation include the over 100 skulls assessed by A. E. W. Miles in order to formulate his renowned dental ageing chart based on tooth wear. These skeletal remains were unearthed from an Iron Age camp at Breedon-on-the-hill in Leicestershire, England, during the 1940s. Miles measured the areas of occlusal wear facets on the molar teeth and thereby calculated a rate of attrition through the stages of complete eruption to old age. The skulls used in this study are stored alongside Miles' original notes for each individual.

A diverse range of archaeological sites are represented in the collection, on both a temporal and geographic scale. Remains from seven Romano-British sites have been incorporated, the large majority of which have complete dental arcades and generally show little dental displacement or disease. Furthermore, over 100 cranial specimens have been donated from two medieval burial sites in central London. Both of these populations show a range of non-metric traits and pathologies, including microdontia, supernumerary teeth and diseases that generally correlate with poor oral hygiene. Finally, there is a broad geographic range of archaeological sites represented in the collection, including three Egyptian mummy skulls and four Guanche mandibles (the indigenous inhabitants of the Canary Islands).

The human material is a rich resource for the study of dental development, as all ages are represented, both in skeletal form and in casts or models. Over 200 sets of perinatal dentitions were collected during the 1950s and have subsequently been used to form the basis of doctoral research into the construction of a new dental ageing atlas, which is currently available through the Queen Mary University of London website (AlQahtani, 2008). Other material shows abnormalities in dental placement, from simple transpositions to the eruption of teeth into the zygomatic bone or even into the nasal fossa. All varieties of non-metric traits have been noted in the extensive array of individual mounted teeth showing the gradations of such anomalies (Fig. 2). Sets of molars have been mounted to effectively show the varying degrees of supernumerary cusps, such as parastyles and the cusp of Carabelli. Similarly, traits such as microdontia, anodontia and the presence of supernumerary teeth can be seen in prepared sections of the mandible and maxilla (Fig. 3). In addition to the skeletal and dental specimens, the large collection of dental casts illustrates a range of diseases and injuries, from congenital abnormalities such as cleft palates in their respective stages of repair, to maxillofacial gun shot injuries of soldiers from the First and Second World wars.

Concurrently, there are a few human specimens housed within the collection that do not relate specifically to the categories of development or pathology, but are potentially of a wider anthropological value. Examples include several skulls displaying variations in intentional modification of the dentition through dental filing, chipping or staining. Casts have been included

Fig. 3. The maxillae showing abnormality in positioning of the teeth and the presence of supernumerary teeth. The normal positions of the central incisors are occupied by two tubercle-shaped teeth. The left central incisor is misplaced and the right central incisor appears absent. From the collection of Sir Edwin Saunders.

alongside this sample to show variations in modification between cultural groups. A large proportion of these crania are Javanese in origin, having been donated by the anthropologist Joseph Barnard Davis in the late nineteenth century (Fig. 4). The effect of occupational or habitual activities on the dentition is a related theme. Such use of the teeth as tools is noticeable in the casts of Eskimo teeth depicting the practice of leather softening through mastication and the various sections of jaws showing pipe facets.

While approximately one-third of the collection is composed of human material, the remaining two-thirds consist of crania from a range of faunal taxa. Of the over 7,000 animal cranial specimens, some 4,000 are primates, including a significant number of specimens donated by the late primatologist Sir William Osman Hill. A wide variety of primates are represented in the collection, from the largest, the gorilla, to the smallest, the mouse lemur. This diversity in both animal species and geographic habitat holds the potential for extensive comparative study. Of the extinct species represented, the large majority are fossilised specimens that hold the potential for paleontological investigation. However, specimens of the more recently extinct Thylacine Wolf (Thylacinus cynocephalus) are incorporated in the collection as complete skulls or partial maxillae and mandibles. The collection also contains over 250 carved and un-carved ivory specimens that originate from both terrestrial and marine mammals, which could be used to form the crux of a variety of research projects. The range of species, the geographical spread of the collection, and the quantity of specimens stored, make the faunal material a valuable resource for comparative studies, especially in the field of evolutionary anatomy.

The latest stage in the recataloguing of the Odontological Collection began last October, with an aim to be completed by the end of 2010. All specimens are now listed on the online catalogue 'surgicat' and can be searched by anyone with internet access at http://surgicat.rcseng.ac.uk/. The initial search page of surgicat contains a 'free search' box under which one can search for specimens recorded under any category. A broad search of criteria such as taxon name, pathological term or acquisition source will promptly detail all relevant records in the museum's collections. For more specific searches, or to combine a set of queries, the 'expert search' system can be used. The human collection is now fully documented and all specimens are recorded by description and have attached photographs where relevant. Recataloguing the animal material began in July of this year and is an ongoing project. The Odontological Collection is an unparalleled source of dental information, the potential of which is yet to be fully realised. It is hoped that this overview provides some insight into the sheer scope of the odontological material contained and encourages prospective enquirers to refer to the collection in future study.

Fig. 4. Cranium of a 25 year old male from the Maluku Islands, Indonesia, showing modification of the anterior teeth. Quadrilateral reliefs have been filed into the labial surfaces. The left central incisor was lost post-mortem. Donated by Joseph Barnard Davis in the late 19th century.

For details on accessing The Odontological Collection, or for any further help with performing surgicat searches, please contact Milly Farrell (mfarrell@rcseng.ac.uk).

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RESEARCH COMPETITION in DENTAL ANTHROPOLOGY

THE ALBERT A. DAHLBERG PRIZE

The Albert A. Dahlberg Prize is awarded annually to the best student paper submitted to the *Dental Anthropology Association* (*DAA*). Dr. Dahlberg was a professor at the University of Chicago, one of the founders of the International Dental Morphology Symposia, and among the first modern researchers to describe variations in dental morphology and to write cogently about these variations, their origins, and importance. The prize is endowed from the Albert A. Dahlberg Fund established through generous gifts by Mrs. Thelma Dahlberg and other members of the association.

Papers may be on any subject related to dental anthropology. The recipient of the Albert A. Dahlberg Student prize will receive a cash award of $200.00, a one-year membership in the Dental Anthropology Association, and an invitation to publish the paper in *Dental Anthropology*, the journal of the association.

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The manuscript should be accompanied by a letter from the student's supervisor indicating that the individual is the primary author of the research and the paper. Multiple authorship is acceptable, but the majority of the research and writing must be the obvious work of the student applying for the prize. Send enquiries and submissions to the President of the *DAA*:

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