INVESTIGATING VARIABILITY IN HUMAN DENTAL DEVELOPMENT IN THE PAST

ABSTRACT: An initial comparison of long bone size between a nineteenth century Canadian skeletal sample and an Imperial Roman sample used the dental formation standards of Moorrees, Fanning, and Hunt (1963a,b) to estimate chronological age. The two samples appear similar until 8 years when the Roman sample falls below the Canadian one. This method of comparison assumes that the patterns of dental formation are the same in the two samples. But there is a body of research which shows either genetic or environmental effects on dental development. The two samples were compared using tooth pairs at various stages of formation, independent of any other population standards. No significant differences were found. However, sampling problems may mimic patterned differences in dental development and be affected by biases in archaeological mortality samples. The absence of differences in patterns of dental formation between these two samples confirms that there are no micro-level genetic differences between them or environmental differences that might affect dental formation, despite the considerable evidence for skeletal stress in the Roman sample. Shorter stature in the Roman sample, manifested in later childhood, reflects expectations for population differences in skeletal size.

KEY WORDS: Tooth formation – Dental development – Population variability – Skeletal growth

Careful age at death estimation is critical to the investigation of immature human skeletons whether they are fossil specimens or come from more recent archaeological sites. In 1984, the nearly complete juvenile skeletal remains of an early hominid (KNM-WT 15000) were found at the site of Nariokotome in northern Kenya. This discovery accelerated research into comparative primate (and specifically hominid) dental and skeletal development. Shortly after, considerable debate was generated around the evolutionary timing and appearance of the extended growth period seen in modern humans (Bromage, Dean 1985, Bromage 1987, Mann et al. 1987, 1990, Lampl et al. 1993). Palaeoanthropology researchers recognised at that time that there was a need for an independent, chronological, and quantitative method for judging the age at death of fossils so that comparative growth and development could be evaluated and compared between specimens and species.

The desired method has been found in microscopic methods for calculating the timing and duration of production of dental tissues, both before and after birth (Fitzgerald et al. 1999, Antoine et al. 1999). These methodologies have almost entered the mainstream of dental anthropology research. But the microscopic approach is invasive, still time consuming, and currently restricted to relatively small samples. In the field of bioarchaeology, or, the skeletal biology of more recent human populations, the radiographic assessment of the developing dentitions of subadults has become the accepted approach to evaluating age in large samples (Ubelaker 1989, Saunders 1992, Saunders, in print). While radiographic studies have been criticised and considered limited in their ability to precisely determine dental developmental events for fossils (Macho, Wood 1995) it will be some time before histological sampling of teeth from human populations in the present and in the past
In the last two decades, there have been some demonstrations of broad population differences in tooth development which are contrary to expected effects from environmental stress. African populations and Aboriginal North Americans (which might be shown to be environmentally disadvantaged) have been found to be advanced in tooth formation compared to Europeans and white North Americans (Cherckow 1980, Owsley, Jantz 1983, Harris, McKee 1990, Tompkins 1996). There are also more localized indications of maturation differences which might be interpreted as environmentally based. A modern study of tooth maturation in Sardinian children found the Sardinian children to be delayed up to one year relative to the MFH data for the six post-inferior mandibular permanent teeth (Diaz et al. 1993).

An interesting approach to investigating patterns of dental development is that taken by Tompkins (1996) who assessed the differences in patterns of dental development by directly comparing formation stages of various teeth relative to the attained maturation status of a reference tooth in three samples, French-Canadians, black South Africans, and a mixed group of Aboriginal North Americans. This method allows the use of the represented archaeological samples since the knowledge of actual chronological age is not required. Patterns of formation can be searched for differences but the determination of the causes of any differences has to be determined by other independent evidence. Tompkins observed delayed molar development in the French-Canadian sample when compared to the other two groups, in support of earlier observations of Cherckow (1980), Owsley, Jantz and Harris and McKee (1990). In the current study, we compared the formation of several deciduous and permanent teeth for the Isola Sacra and St. Thomas' samples relative to the attained formation status of a reference tooth to look for any evidence of population-based differences in dental development.

MATERIALS

The necropolis of Isola Sacra, about 23 km west of Rome, Italy, was used by the inhabitants of Porus during the second and early third centuries A.D. In A.D. 41, Emperor Claudius ordered the construction of a sea harbour north of the mouth of the river Tiber. The plan was to improve on Ostia, a river port, which did not permit anchorage in all weather and seasons. The first harbour was only completed by Emperor Trajan in the second century A.D. Portus served as the port of Rome directing important goods such as grain into Rome until the decline of the imperial city. The transition to the period when Portus was in its prime. It is composed of a wide variety of burial structures such as sand, brick of wooden coffins, amphorae, and terracotta sarcophagi interspersed among monumental multiple tombs. The occupants of the necropolis generally represent a kind of "middle class" of merchants and tradespeople as well as freed slaves.

METHODS

Jantz and Owsley (1994) have developed a method for deriving schedules of dental development that are specific to populations. The first step is to estimate the birth length of each long bone using the perinatal distribution of bone lengths. This is designed to establish a chronological start point for development to which a second estimate of birth length, derived from age estimates associated with particular tooth development stages, is compared. By this means, the difference between the assumed newborn size and newborn size based on an external dental development standard, can be compared. If two different archaeological samples are then compared, the method allows chronological age to be estimated from corrected dental ages so that skeletal growth can be evaluated. This method relies on the assumption that infants around the time of birth have the highest probability of dying. This is not necessarily true (see Saunders 1992, in print). In the St. Thomas’ and Isola Sacra samples, as with many skeletal samples, there are no high concentrations of individuals around a particular long bone length that might identify

FIGURE 1. Comparisons of distributions of femur diaphyseal length plotted against MFH dental age estimates for Isola Sacra and St. Thomas’, Belleville samples.
TABLE 1. Kolmogorov-Smirnov two group tests of tooth formation - comparisons for Isola Sacra and St. Thomas.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Probability</th>
<th>D.F.</th>
<th>Critical value at p = 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>dm1 × M1</td>
<td>0.3664</td>
<td>2</td>
<td>0.2665</td>
</tr>
<tr>
<td>dm2 × M1</td>
<td>0.2382</td>
<td>2</td>
<td>0.2617</td>
</tr>
<tr>
<td>M1 × M2</td>
<td>0.3811</td>
<td>2</td>
<td>0.3211</td>
</tr>
</tbody>
</table>


DISCUSSION

This analysis did not discover any evidence of patterned differences in tooth formation between the Imperial Roman period Isola Sacra sample from Italy and the nineteenth century British-based sample from Canada. This suggests that any comparisons of skeletal growth between the two populations, using the same standards for dental formation, are valid.

It should be noted that observations of both the matrices of comparison of tooth formation stages which present the raw data (Figures 2 to 4) and a comparison of the cumulative percentage frequency distributions of the tooth formation stages (Figure 5) suggest there is a difference between Isola Sacra and St. Thomas' towards the ends of M1 formation. The Isola Sacra sample lacks cases in the latter stages of M1 formation, which suggests a delay in formation. But the statistical analysis indicates that this difference is not significant. A closer inspection of Figure 1 shows that a deficiency of cases in the Isola Sacra sample at around three years of age accounts for the gap. This should serve as a reminder to researchers that biases in archaeological mortality samples may sometimes mimic apparent biological differences.

The absence of any differences in patterns of dental development between the two samples negates any expectations either of micro-level genetic differences in dental development between populations or differences due to environmental factors that might affect dental formation. Tompkins (1997) found broad population differences in dental formation patterns between native Americans, French Canadians and black South Africans. Watt and Lunt (1998) also report differences between a Scottish sample and the French Canadian sample studied by Tompkins. The
Isola Sacra and St. Thomas' samples, although both of European origins, are widely dispersed in both space and time. It would be worthwhile having further information on more geographically localised populations over time to search for environmentally based differences in dental development.

Returning to the skeletal data, we can say that there are no obvious differences between the two samples in patterns of skeletal size increase. The St. Thomas' sample has previously been shown to be similar to modern North American children in terms of skeletal size increase. The Roman sample does not fall short of the St. Thomas' sample until about 8 years of age. Since the correlation between final stature and stage childhood increases dramatically into late childhood (Tanner 1978), and early childhood is the more risky period in terms of chronic growth stunting, this would suggest that the Roman sample becomes shorter at 8 years due to a reduced growth potential for genetic reasons. It does not rule out the possibility of the influence of environmental factors on skeletal growth in the Roman sample. Other investigations of the samples have identified the presence of chronic diseases affecting the skeleton (Rossi et al. 1999). But the absence of substantive differences in diaphyseal size between the Isola Sacra sample and St. Thomas' at early ages, in contrast to other studies (Hoppa 1992, Saunders et al. 1993) suggests that there was ample opportunity for catch up growth. This could be investigated further by examining other aspects of development in these two samples. Further research on the Isola Sacra sample will take this approach.

**APPENDIX A.**

<table>
<thead>
<tr>
<th>MFH Bone</th>
<th>MFH Perm.</th>
<th>Denomination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co4</td>
<td>Co4</td>
<td>C1</td>
</tr>
<tr>
<td>Co5</td>
<td>Co5</td>
<td>C2</td>
</tr>
<tr>
<td>Cr1/2</td>
<td>Cr1/2</td>
<td>C3</td>
</tr>
<tr>
<td>Cr3/4</td>
<td>Cr3/4</td>
<td>C4</td>
</tr>
<tr>
<td>Cr5/6</td>
<td>Cr5/6</td>
<td>C5</td>
</tr>
<tr>
<td>R1/2</td>
<td>R1/2</td>
<td>D1</td>
</tr>
<tr>
<td>R1/2</td>
<td>R1/2</td>
<td>D2</td>
</tr>
<tr>
<td>R1/2</td>
<td>R1/2</td>
<td>D3</td>
</tr>
<tr>
<td>Re</td>
<td>Re</td>
<td>E1</td>
</tr>
<tr>
<td>Re</td>
<td>Re</td>
<td>E2</td>
</tr>
<tr>
<td>Ac</td>
<td>Ac</td>
<td>H1</td>
</tr>
</tbody>
</table>

**REFERENCES**


SCHEUER I., MARSHALL M. C., 1944: Development of the human dentition. 2nd ed. American Dental Association, Chicago.

