Chapter 7

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Dental enamel hypoplasia, age at death, and weaning in the Taung child

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Abstract

Since its discovery in 1924, the Taung child has been one of the most widely studied hominid fossils. However, a feature so far unrecorded in this juvenile specimen is the presence of dental enamel defects known as linear enamel hypoplasias (LEH) on its first permanent molars. These abnormal phases of enamel growth are associated with episodes of trauma, illness or malnutrition and differ in morphology from external normal growth lines or perikymata. The LEH appear 11 perikymata (approximately 11 weeks) from the cervix on the M_1 and 13 in the M^1. Using a circaseptan periodic appearance of perikymata during enamel development and M^1 crown formation time obtained for other *Australopithecus africanus* specimens, we suggest that the Taung child experienced a stress period during life at about 2.5 years of age, which led to the development of the LEH. As this age is broadly coincidental with weaning in modern humans, we further investigated whether there might be a relationship with the LEH of Taung . Given crown development in M^1 of *A. africanus* (Stw 402) and root length developed in Taung M^1, we suggest that the age at death of this individual took place between 3.75 to 3.95 years, slightly later than originally proposed.

Introduction

The holotype of the Plio-Pleistocene hominid species *Australopithecus africanus*, the "Taung child" described by Dart[1] is probably the most widely studied hominid fossil. The dentition of the Taung child preserves all the deciduous teeth and all four first permanent molars, which had just come into occlusion and had approximately 5-6 mm of root developed on the first permanent molars[2].

The aims of this study are threefold: 1) re-assess Taung's age at death based on crown formation time of M^1 in *A. africanus* 2) describe enamel defects on the first permanent molars of Taung and 3) investigate the possibility that weaning could have been the cause of these defects.

Based on its dental development, the age at death of Taung has been estimated at about 3.3 years by means of comparison to an individual of the same species and dental formation status, Sts 24 + 24a, whose enamel incremental features were available for study[3,4]. The formation status of the developing incisors was predicted by these studies, but subsequently corroborated by computerized tomography which suggested an age of 3.5 years[2]. A more recent review[5] on the incremental lines of the *A. africanus* specimen Sts 24 showed a difference of only three additional perikymata in relation to the original study. Although other studies[6] have indicated that the growth of anterior teeth in *Australopithecus* may have been longer than originally proposed[4], no changes in the age at death of the Taung child have been suggested. Recently[7], a period of 2.74 years was estimated for the development of the crown on the specimen Stw 402 (RM^1) using lateral striae counts and methods for cuspal enamel development described in ref. 8. Additionally, using a sample of seven molars of this species, these authors found a mean

cross striation periodicity of seven days in this sample[7]. Using this new information, we compared the original age at death based on incisor growth with M^1 crown and root growth.

Moreover, a feature so far unrecorded in the dentition of the Taung child is the presence of a linear enamel hypoplasia (LEH). The hypoplasia in Taung is most evident on the disto-lingual aspect of the entoconid of the right M_1 (Figure 1) and on the lingual aspect of the right M^1 due to small breaks on the alveolar bone. LEH occur during enamel formation due to disruptions in the secretory activity of enamel forming cells (ameloblasts) which generally causes localized thinning of the enamel[9]. Although several physiological "stressors" like trauma, infection and in some cases, emotional stresses are associated with LEH[9,10,11,12], the etiology of these defects in archaeological or palaeontological specimens cannot be ascertained with confidence. In some cases it is coincident in time of the LEH with an expected or predicted life history event that allows for their interpretations. For primates, the social environment is considered to be an important factor influencing their life histories[13]. For instance, weaning and the mother's rejection of the infant following the first post-partum mating period are suggested to cause the appearance of LEH in humans and other primates[14,15,16,17,18] (but see ref. 19). We thus also considered the LEH as possibly related to weaning in Taung child.

Enamel Development

Tooth enamel development is a highly coordinated process that involves simultaneous tissue growth in two directions. First, cells become differentiated from the cusp to the cervix along the enamel dentine junction (EDJ), and second, once these cells acquire competence they secrete enamel from the EDJ to the outer enamel surface

(OES)[20]. During these processes, variations in cell rhythms result in the formation of growth lines within enamel which include daily cross striations, which result from a circadian variation in the rate of matrix secretion by enamel forming cells, and striae of Retzius, which are more pronounced growth lines showing a variable repetitive period across primates[21]. The mean of this periodicity is 6 days in chimpanzees[22] and 9 days in modern humans[5]. Further to this, striae of Retzius regularly emerge at the tooth surface as periodic features called perikymata. Evaluation of these growth structures provides the basis for calibrating fossil hominid development and life history[4,23,24].

Materials & Methods

Maxillary and mandibular first permanent molars of the Taung specimen were replicated using Coltene President putty and light body moulds. Expoxy resin replicas were made from each mould. Incident light microscopy at about 25 times magnification was used to count perikymata cervical to the LEH. SEM images were then obtained for this region of the teeth showing the LEH.

A recent study on crown formation time in *A. africanus*, suggested a period of about 2.74 years for the formation of the M^1 on Stw 402 by counts of lateral striae and calculations of cuspal enamel formation[7]. The same study showed that the mean periodicity in a sample of seven molars of *A. africanus* was seven days between striae, and hence between perikymata. Using this information, and knowing that first permanent molars begin to calcify at around birth[25], we can infer the age at which Taung experienced the stress episode that induced the LEH. The recorded root length on Taung[2] M^1 and the estimated age of M1 eruption for *A. africanus* (3.4 years[26]) allow us to infer

the approximate age at death of this juvenile hominid using another methodology than previously employed.

Further, we investigated whether LEH might possibly be related to weaning in the Taung child. Permanent molars attributed to this species were studied with the use of low-magnification stereoscopic microscopy to assess the presence of LEH in other molars of this species.

Results and Discussion

The LEH present in the molars of Taung corresponds with a deep groove that can be observed along the exposed areas of the crown. It is clear that enamel is thinner at the point where the LEH is present (Figure 2). Eleven and 13 perikymata respectively are present on lower and upper permanent molars of Taung between the LEH and the cervical-most enamel (Figure 3). Five perikymata were counted in the LEH. Using a periodicity of seven cross striations, or in other words, a period of seven days between each perikymata in *A. africanus*, and using the number of perikymata between the LEH and the cervix, the hypoplasia in this specimen developed roughly 0.21 years before the completion of the M_1 crown, or 0.24 years on the M^1. If we assume a period of crown formation time for the M^1 of Taung of approximately 2.74 years, which is within the ranges of molar development reported for other fossil hominid taxa[27,28,34], we may suggest that this individual underwent a physiologically significant stress episode during life at about 2.53 years of age, which is the broad age at which weaning takes place in modern humans[29]. To further investigate this, we analyzed 21 mandibular and maxillary first permanent molars of *A. africanus* for LEH. As the location of the LEH in Taung is

positioned near the cervix, occlusal wear did not affect our study. Our results indicate that only Taung recorded a LEH on this tooth type. A recent study by Guatelli-Steinberg[30], did not find LEH present in any first permanent molars of *A. africanus*, although these enamel defects were common in other tooth types. Thus, it is reasonable to exclude weaning as the possible cause of LEH occurrence in the first permanent molars of the Taung child, and to suggest that the LEH developed most likely as the result of illness, trauma or some other stress-related event at about 2.53 years of age.

The root length on the Taung M^1 is about 5 -6 mm^2. Rates of root development in hominids range between 13- 24 microns/day[31]; 9-15 microns/day [32], 14 microns/day[33] and 10.7 microns/day[34]. Using the average of these rates, about 13.5 microns/day, it would have taken about 1.01 to 1.21 years for the roots of Taung to form. This places Taung's age at death, the sum of crown and root development, between 3.75 to 3.95 years, which is slightly older than previously suggested.

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Figure Legends:

Figure 1. Taung's original fossil showing the location of the linear enamel hypoplasia (LEH) on the lingual aspect of the Rm_1. The LEH were most visible on the entoconid of the right m_1 and the hypocone of the upper M^1.

Figure 2. SEM image of the disto-lingual aspect of Taung's lower right first molar. The hypoplasia, marked with bold white arrows, is evident near the cervix of the crown as a depression of the enamel surface. Normal perikymata (small black arrows) can be seen on both sides of the hypoplastic groove.

Figure 3. SEM image of the cervical end of the lower right M_1 of Taung indicating the location of the LEH (bold black arrow). Smaller arrows mark the number of perikymata between the LEH and the cervix of the tooth. On this specimen, 11 perikymata were present, which are equivalent to approximately 11 weeks.

Figure 1.

Figure 2.

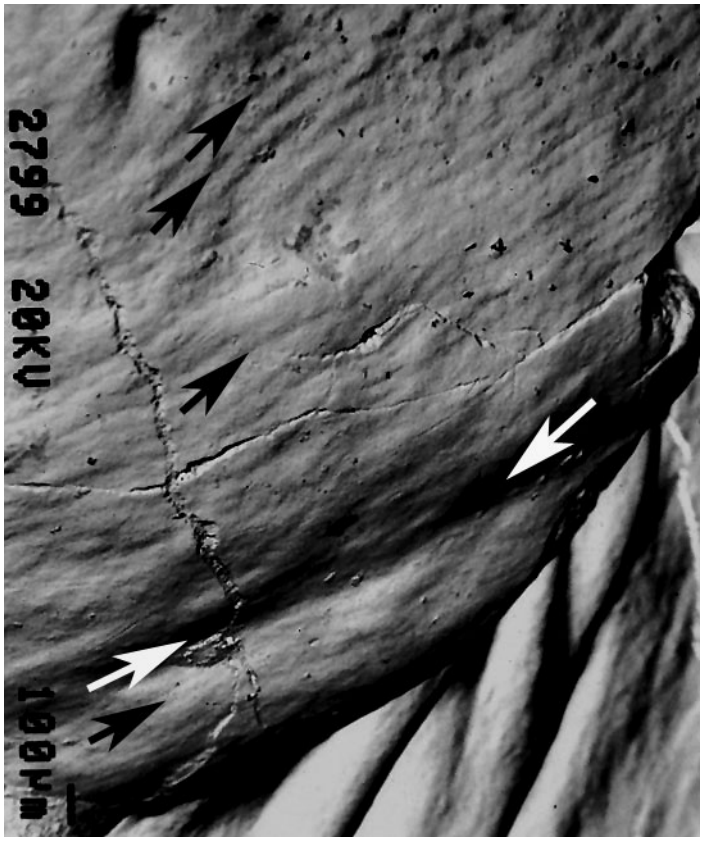

Figure 3.