Quaternary International 405 (2016) 3–10

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Chronology and periodicity of linear enamel hypoplasia mmong Late/Final Jomon period foragers: Evidence from incremental microstructures of enamel

Daniel H. Temple

Department of Sociology and Anthropology, George Mason University, Fairfax, VA, 22030-4444, USA

A R T I C L E I N F O

Article history:
Available online 13 January 2015

Keywords:
Linear enamel hypoplasia
Perikymata
Life history
Stress
Weaning

A B S T R A C T

This study estimates age-at-defect formation and periodicity of linear enamel hypoplasia (LEH) using incremental microstructures of enamel. Results are compared to previous studies and between sites from different regions of Japan (Costal Honshu, Inland Honshu, and Hokkaido). High resolution impressions were collected from the dental remains of 32 individuals from nine archaeological sites. Casts were produced from these impressions and studied under an engineer's measuring microscope. LEH were identified based on enamel surface depressions and accentuated perikymata. Age-at-defect formation was estimated using histological methods. LEH periodicity was estimated using counts of perikymata between defects. Age-at-defect formation ranged between 1.1 and 5.8 years, while interquartile ranges were between 2.9 and 4.1 years. LEH periodicity ranged between 0.1 and 1.7 years, with an average of 0.2 years. There were no significant differences in average age-at-defect formation between regions. Significantly higher LEH periodicities were observed among Jomon foragers from Hokkaido and Inland Honshu compared to Coastal Honshu. Earlier ages-at-defect formation and lower stress periodicities were found by this study compared to earlier research. These differences are attributed to the inclusion of individuals with intact tooth crowns and use of objective, microscopic methods to identify LEH. The interquartile ranges for ages-at-defect formation are consistent with isotopically estimated ages for reductions in breast milk consumption. The lack of differences in average age-at-defect formation between geographic groups may reflect similar environmental stress burdens associated with this process. Comparatively shorter intervals between defects among Late/Final Jomon foragers from Coastal Honshu suggest elevated ecological stress burdens among this sample.

1. Introduction

Linear enamel hypoplasia (LEH) is a condition associated with grooves or furrows observed on tooth crowns, where insufficient enamel is deposited during the secretory phase of amelogenesis (Goodman and Rose, 1990, 1991). Enamel production is stopped earlier than normal resulting in a depression in the enamel surface and accentuated striae of Retzius (Hillson, 1996). The process is mostly transitory as the gradual return to prismatic shape of enamel rods is reported in the cervical walls of defects (Boyd, 1970; Hillson and Bond, 1997). LEH most often form in response to increased energetic burdens associated with nutritional deprivation and infectious disease, though congenital anomalies and traumatic injuries are also causative agents (Suckling and Thurley, 1984; Suckling et al., 1986; Goodman et al., 1991; May et al., 1993; Hillson, 1996; Zhou and Corruccini, 1998). Because teeth do not remodel and enamel is laid down in a chronological fashion, LEH provide an indelible marker of growth disruptions experienced at specific ages during the course of ontogeny—the defects remain permanently observable in teeth, and it is possible to estimate the age at which these disruptions occurred (Hillson, 1996).

Studies of LEH chronology estimate the ages-at-defect formation in a wide variety of contexts. Estimating age-at-defect formation in dental samples provides evidence of adaptive challenges that humans encountered and that biological and cultural buffering systems were often swamped, resulting in physiological perturbation to the individual (Goodman et al., 1988). By and large, bioarchaeological studies report increased LEH prevalence between 2.0 and 4.0 years of age (reviewed by: Larsen, 1997; Hillson, 2014),

E-mail address: dtemple3@gmu.edu.

http://dx.doi.org/10.1016/j.quaint.2014.12.006
1040-6182/Published by Elsevier Ltd..

though there is some variability in this range (Goodman and Song, 1999). For example, ages-at-defect formation in samples of enslaved Africans from Barbados are consistent with age-at-breast-feeding cessation and suggest that stressors associated with this process may have produced LEH in these samples (Corruccini et al., 1985). By contrast, age-at-defect formation in a sample of enslaved African Americans from 18th and 19th century plantations in Maryland and Virginia are distributed at ages after the initiation of the weaning process suggesting other environmental factors such as infectious disease and malnutrition were associated with these defects, though the possibility for overlap between weaning and LEH at earlier ages is still considered a plausible interpretation (Blakey et al., 1994). Importantly, however, a number of studies argue that these distributions are potentially biased by tooth crown geometry: striae of Retzius outcrop onto the enamel surface at less acute angles in the occlusal compared to cervical sections of a tooth, causing LEH to be poorly defined, and quite possibly, inflating peak ages for growth disruption in archaeological samples (Goodman and Armelagos, 1985; Blakey et al., 1994; Hillson and Bond, 1997; Guatelli-Steinberg et al., 2012).

LEH periodicity addresses the amount of time between successive defects. Macroscopic studies infer seasonal stress patterns based on LEH periodicity in Pliocene hominines, fossil primate, modern human, and Great Ape dental samples (Macho et al., 1996, 2003; Nelson, 1999; Skinner and Hopwood, 2004). Among modern humans, microscopic approaches have also yielded evidence for greater stress burdens in the Medieval compared to historic inhabitants of London based on differences in LEH periodicities between the two samples (King et al., 2005). Couched within the findings of these studies is evidence that microscopic methods yield considerably lower periodicities than macroscopic approaches. This difference may reflect the ability of microscopic methods to identify more LEH or to count perikymata between defects rather than measuring the distance between LEH. Overall, these studies suggest that LEH periodicity is an important component to the evaluation of stress in past populations, and that microscopic approaches may yield more precise evidence for the periodicity of these growth disruptions.

Jomon foragers are the descendants of a Paleolithic population that migrated into Japan around 25,000 BP (Imamura, 1996; Kobayashi, 2005). One set of hypotheses suggests that the ancestors of these Paleolithic migrants were from Southeast Asia (Hanihara, 1991), while another argues that the ancestors of Jomon people originated in Northeast Asia (Omoto and Saitou, 1997; Pietrusewsky, 1999; Hammer et al., 2006; Hanihara and Ishida, 2009; Adachi et al., 2009, 2011). Recent samples of ancient-DNA dated to the Initial phase of the Jomon period reveal that these populations were genetically heterogeneous and that conclusions regarding the early affinity of these groups should be cautiously interpreted (Adachi et al., 2013).

The prevalence of individuals with LEH was explored among prehistoric Jomon people from different regions of Japan, and differences in these frequencies were associated with variation in resource availability, dietary quality, and infectious disease (Shigehara, 1994; Koga, 2003; Temple, 2007, 2010; Oxenham and Matsumura, 2008). Elevated frequencies of individuals with LEH are, however, a hallmark of many Jomon dental samples (Yamamoto, 1992; Shigehara, 1994; Koga, 2003; Temple, 2007, 2010; Hoover and Matsumura, 2008; Sawada et al., 2008; Temple et al., 2013). Thus, regional variation in LEH prevalence among Late/Final Jomon period people remains an open question.

One study explored LEH chronology and periodicity among Late/Final Jomon period people, and suggested that LEH are distributed between 2.5 and 5.5 years of age and have periodicities between 0.4 and 0.9 years (Yamamoto, 1992). Unfortunately, this study did not use microscopic methods to identify LEH, so many defects may not have been observed (Hillson and Bond, 1997; King et al., 2002; Temple et al., 2012). In addition, the chronologies of LEH reported by Yamamoto (1992) were estimated using models that assume a linear rate of tooth growth. These methods are no longer accepted standards as histological studies have demonstrated a non-linear rate of crown growth (Reid and Dean, 2000, 2006) and methods to estimate age-at-defect formation based on histological estimations of tooth crown growth are decidedly more accurate (Ritzman et al., 2008).

Using previous research on LEH among Late/Final Jomon period people as a framework, this study has several goals regarding the estimation of age-at-defect formation and LEH periodicity among these samples. First, ages-at-defect formation and LEH periodicities will be compared to the results of previous studies (i.e., Yamamoto, 1992). In addition, the distribution of age-at-defect formation among Late/Final Jomon period people will be used to best infer the environmental hazards associated with LEH formation. Finally, average age-at-defect formation and LEH periodicity will be compared between georgraphic groups (Coastal Honshu, Inland Honshu, and Hokkaido) to evaluate the possibility of variation in stress burdens between Late/Final Jomon period foragers from different ecological zones.

2. Materials and methods

2.1. Materials

All archaeological sites yielding dental remains utilized by this study are mapped in Fig. 1. Table 1 lists the number of individuals ($n = 32$) with dental remains that had observable perikymata, teeth, and matched-LEH by region. The number of individuals with observable perikymata is significantly lower than the number of individuals with macroscopically observable LEH reported by earlier studies (Temple, 2007, 2010). The number of individuals with observable perikymata is small because of taphonomic factors influencing preservation of enamel microstructures, the inclusion of individuals with 90 percent or more of observable crown height (see below), and the need to match LEH on more than one tooth.

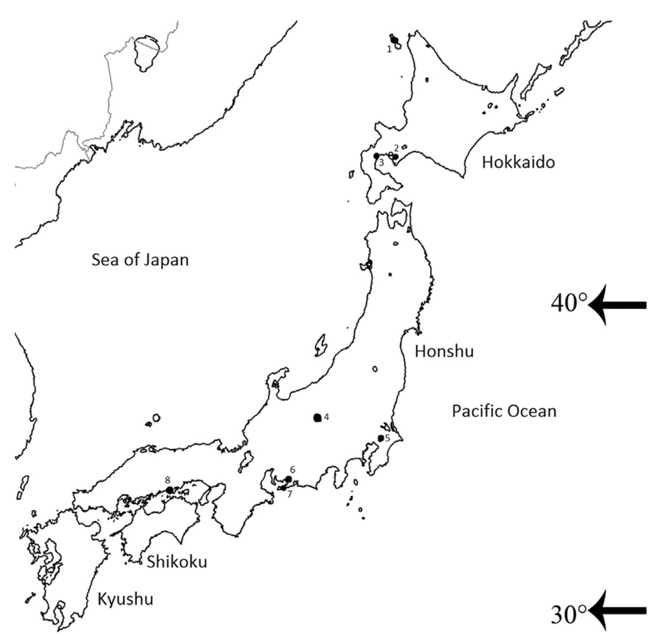

Fig. 1. Archaeological sites that yielded dental remains used in this study: 1, Funadomari; 2, 2, Takasago; 3, Koten-Onsen; 4, Kitamura; 5, Nakazuma; 6, Inariayama; 7, Yoshigo; 8, Tsukumo.