4. New perspectives on chimpanzee and human molar crown development

T.M. SMITH
Human Evolution Department, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, D-04103 Leipzig Germany
tsmith@eva.mpg.de

D.J. REID
Department of Oral Biology, School of Dental Sciences Newcastle University, Framlington Place Newcastle upon Tyne NE2 4BW, U.K.
D.J.Reid@newcastle.ac.uk

M.C. DEAN
Department of Anatomy and Developmental Biology University College London Gower Street, London WC1E 6BT, U.K.
ucgacrd@ucl.ac.uk

A.J. OLEJNICZAK
Human Evolution Department, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, D-04103 Leipzig Germany
olejniczak@eva.mpg.de

R.J. FERRELL
Assistant Professor
Department of Sociology & Anthropology
Howard University
2441 6th St. NW Washington, DC 20059
rferrell@howard.edu

L.B. MARTIN
Departments of Anthropology and of Anatomical Sciences
Stony Brook University
Stony Brook, NY 11794-4364
U.S.A.
lawrence.martin@stonybrook.edu

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Abstract

Previous histological studies of small samples of chimpanzee and human molars suggested similarities in crown formation time, which is surprising given substantial life history differences. As part of an on-going study of hominoid molar development, we report on the largest-known sample of chimpanzee and human molars, including re-evaluation of previously examined histological sections. Variation of incremental features within and between genera is examined, including Retzius line periodicity, daily secretion rate, and Retzius line number. Differences due to population-level variation and sexual dimorphism are also considered. Significant increasing trends in daily secretion rates were found from inner to outer cuspal enamel, ranging from approximately 3–5 microns/day in chimpanzees. Humans demonstrate slightly lower and higher mean values at the beginning and end of cuspal formation, respectively, but both genera show an overall average of approximately 4 microns/day. Retzius line periodicity ranges from 6–7 days within chimpanzees and 6–12 days within humans. Within upper molars, mesiopalatal cusps (protocones) show thicker cuspal enamel and longer crown formation time than mesiobuccal cusps (paracones). Within lower molars, mesiobuccal cusps (protoconids) show greater Retzius line numbers, longer imbricational formation time, and thicker cuspal enamel than mesiolingual cusps (metaconids), resulting in longer formation times. A negative correlation was found between Retzius line number and periodicity in the human sample, resulting in similar crown formation times within cusp types, despite the range of individual periodicities. Few sex differences were found, but a number of developmental differences were apparent among human populations. Cusp-specific formation time in chimpanzees ranges from 2–3 years on average. Within specific cusp types, humans show greater average formation times than chimpanzees, due to higher mean periodicity values and/or thicker cuspal enamel. However, formation time within specific cusp types varies considerably, and the two genera show overlapping ranges, which has implications for the interpretation of small samples.

Introduction

Recent histological studies of chimpanzee and human enamel crown formation have suggested a number of similarities in molar formation time (Reid et al., 1998a,b). This is unexpected given their life history differences, which include an almost two-fold difference in the age at M1 eruption (reviewed in Kelley and Smith, 2003; but see Zihlman et al., 2004). However, these studies were based on small samples, and included several individuals with moderate to heavy dental wear. Recent studies of hominoid anterior tooth formation have yielded evidence of developmental differences among taxa (e.g., Schwartz and Dean, 2001; Schwartz et al., 2001). Yet little is known about the variation in molar development within and among taxa; postcanine development had been described for only four individuals of *Pan*, two individuals of *Gorilla*, and a lone representative of *Pongo* (Beynon et al., 1991; Reid et al., 1998a; Schwartz et al., 2006). Recently, several researchers have analyzed large collections of diverse groups of modern humans and chimpanzees (Thomas, 2003; Smith, 2004; Reid and Dean, 2006; Reid and Ferrell, 2006; Smith et al., 2007). The current study aims to use these data to highlight and contrast some of the developmental variables in molar enamel within and between modern humans and our closest-living primate relatives. We also attempt to generate a broad comparative framework for the interpretation of developmental data on more limited fossil collections.

The specific objectives are (1) to determine the appropriate units of analysis for developmental variables (e.g., individual, molar, specific molar, specific cusp), and (2) to investigate variation in enamel development at hierarchical levels. Within cusp types and tooth types, we examine several developmental variables: cuspal daily secretion rate, Retzius line periodicity, Retzius line number, imbricational enamel formation time, cuspal enamel thickness, and cusp-specific enamel formation time. We also explore the potential influence of sex and population differences on these variables. Our final comparison is