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Variation in hominoid molar enamel thickness

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Abstract

Enamel thickness has figured prominently in discussions of hominid origins for nearly a century, although little is known about its intra-taxon variation. It has been suggested that enamel thickness increases from first to third molars, perhaps due to varying functional demands or developmental constraints, but this has not been tested with appropriate statistical methods. We quantified enamel cap area (c), dentine area (b), and enamel-dentine junction length (e) in coronal planes of sections through the mesial and distal cusps in 57 permanent molars of *Pan* and 59 of *Pongo*, and calculated average (c/e) and relative enamel thickness (([c/e]/√b) * 100). Posteriorly increasing or decreasing trends in each variable and average (AET) and relative enamel thickness (RET) were tested among molars in the same row. Differences between maxillary and mandibular analogues and between mesial and distal sections of the same tooth were also examined. In mesial sections of both genera, enamel cap area significantly increased posteriorly, except in *Pan* maxillary sections. In distal sections of maxillary teeth, trends of decreasing dentine area were significant in both taxa, possibly due to hypocone reduction. Significant increases in AET and RET posteriorly were found in all comparisons, except for AET in *Pongo* distal maxillary sections. Several significant differences were found between maxillary and mandibular analogues in both taxa. Relative to their mesial counterparts, distal sections showed increased enamel cap area and/or decreased dentine area, and thus increased AET and RET. This study indicates that when AET and RET are calculated from samples of mixed molars, variability is exaggerated due to the lumping of tooth types. To maximize

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taxonomic discrimination using enamel thickness, tooth type and section plane should be taken into account. Nonetheless, previous findings that African apes have relatively thinner enamel than *Pongo* is supported for certain molar positions.

Keywords: Average enamel thickness; Relative enamel thickness; Enamel cap area; Dentine area; Enamel-dentine junction length; Trend analysis; Hypocone reduction; Hominoid evolution

Introduction

Anthropological analyses of dental material have traditionally focused on aspects of gross crown morphology and metrics, patterns of wear, and enamel thickness inferred from exposed areas of dentine. Enamel thickness has been commonly assessed as a linear measurement of enamel visible in worn or naturally fractured teeth, and is often characterized as "thick" or "thin" (e.g., Simons and Pilbeam, 1972: 58, figures 2-3). Martin (1983, 1985) demonstrated that it is difficult to assess enamel thickness accurately from exposed enamel. He measured thickness from buccolingual sections cut through the mesial cusp tips, which could be scaled in relation to a surrogate for body size to make comparisons across taxa, resulting in a measure of relative enamel thickness (RET).

Martin found that gorillas and chimpanzees both had thin enamel, orangutans possessed intermediate-thick enamel, and humans had thick enamel (which was similar to the findings of Gantt [1977] on linear enamel thickness measurements from a controlled plane of section). From these results, Martin proposed that the ancestral hominoid RET condition was thin, as seen in a hylobatid outgroup, and that the ancestral great ape and human condition was thick. Recently, Shellis et al. (1998) suggested that, as the total number of teeth sampled increased, extant hominoids showed slightly different average values than those reported by Martin (1983, 1985). Shellis et al.'s chimpanzee sample was reported to show a range of enamel thickness values that is more similar to that of orangutans (intermediate thickness) than to thin-enameled gorilla teeth. However, Shellis et al.'s method of assessing enamel thickness was based on regression analysis, which may yield different results depending on the composition of the sample (see below). Kono (2004) recently reported two-dimensional (2-D) and three-dimensional (3-D) enamel thickness and crown volume data measured from micro-computed tomographic images of a small sample of hominoid molars. Two-dimensional values of average enamel thickness demonstrate that there exists substantial overlap between *Pan* and *Gorilla*, providing additional support for Martin's (1983, 1985) conclusion.

An obvious limitation of studies of enamel thickness is the partially destructive nature of direct sectioning techniques. Reported hominoid values from a controlled (physical) plane of section have necessarily been based on small sample sizes (Gantt, 1977; Martin, 1983, 1985; Grine and Martin, 1988; Andrews and Martin, 1991; Macho, 1994; Beynon et al., 1998; Shellis et al., 1998; Grine, 2002; Olejniczak and Martin, 2002; Schwartz et al., 2003; Smith et al., 2003b, 2004; Grine, 2005). Previous studies of extant ape molars have produced a maximum reported sample of 17 teeth from seven individuals of a single species (Martin, 1983). Shellis et al. (1998) provided enamel thickness data on a wide range of prosimian and anthropoid molars. However, samples of each species were very small and the majority of molar type values were determined from single teeth. In particular, the issue of increasing enamel thickness from first to third molars within non-human primates remains unresolved (Schwartz, 2000a). If a pattern of increase can be shown, then values derived from different molars serve to increase the variance of combined tooth samples. In this case, enamel thickness should be reported for individual molar positions to maximize the likelihood of detecting differences among taxa (Macho, 1994; Grine, 2002).