3. Dental topography and human evolution with comments on the diets of *Australopithecus africanus* and *Paranthropus*

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Abstract

Dental functional morphology can inform us on the dietary adaptations of early hominins and other fossil primates. Traditional approaches to understanding dental form-function relationships have relied mostly on unworn teeth for analysis. This has limited our samples and our understanding of how teeth are adapted to wear in a manner that keeps them mechanically efficient for chewing. This paper reviews a relatively new tool for the study of occlusal functional morphology, dental topographic analysis. This landmark-free, three-dimensional approach involves the creation and measurement of digital models of teeth using point cloud data and Geographic Information Systems software. Three examples are presented. First, a study of living great apes is reviewed to show that worn teeth can be included in the study of dental topography, and that species with different diets have corresponding and predictable differences in the shapes of their molars at comparable stages of tooth wear. Second, a longitudinal study of howling monkeys is summarized to demonstrate that different individuals within this species have consistent changes in crown shape as their teeth wear down. This suggests species-specific wear patterns, a necessary prerequisite for the inference of function from form of worn fossil teeth. Third, a new dental topographic analysis is presented for *Australopithecus africanus* and *Paranthropus robustus* to illustrate that this approach can offer insights into the dietary adaptations of early hominins and other fossil primates. Results presented here confirm that the *A. africanus* and *P. robustus* differed in their dietary adaptations. The degree of difference between their occlusal morphologies is on the order expected of species that often eat similar foods, but differ at "crunch" times. Dental topography data suggest that *P. robustus* probably fell back more on hard, brittle items whereas *A. africanus* relied on tougher, more elastic foods when preferred resources were less available.

S.E. Bailey and J.-J. Hublin (Eds.), Dental Perspectives on Human Evolution, 321–343.

Introduction

Studies of living primates show us just how important food choices are to the daily lives of these animals. Diet underlies many of the behavioral and ecological differences we observe, from group size and structure to positional behavior and locomotion (see Fleagle, 1999). It should come as no surprise then that primatologists focus considerable attention on documenting even the subtlest aspects of feeding ecology. Such studies allow us to better understand the ecological "role" of a primate species, and how it adapts to the environment in which it lives.

It follows that researchers would view primate (including human) evolution in terms of changing adaptations reflecting changing food resources or patterns of resource exploitation. Diet is therefore an important key to understanding paleoecology of past primates, including early hominins, and many theories concerning human evolution have centered on the feeding adaptations and subsistence practices of our distant ancestors.

Most studies of early hominin feeding behaviors and adaptations have focused on dental remains, because they are so well-suited to reconstructing diet. First, mammal teeth function to procure and process food. These durable parts of the digestive system are often the only surviving link between an extinct species and its diet. Second, teeth are the most abundant elements in most fossil assemblages, so can provide a rich source of data.

There are two distinct lines of evidence researchers look to when reconstructing diet from dental remains: genetic signals, which tell us something about what a species was adapted to eat, and non-genetic or epigenetic signals, which tell us something about what an animal ate during its lifetime. Evidences of adaptation include enamel thickness and structure, dental allometry (tooth size), and dental morphology (tooth shape). Evidences of foods eaten during life include tooth chemistry (e.g., stable isotope ratios) and dental microwear. A consideration of all of these approaches is beyond the scope of this paper; reviews can be found easily enough in the literature (e.g., Ungar, 2002; Teaford and Ungar, 2006; Teaford, 2007).

Background

This chapter considers one line of evidence for dietary adaptation, dental functional morphology. Researchers have recognized for hundreds of years that tooth form reflects function (e.g., Hunter, 1771; Owen, 1840–1841; Cuvier, 1863; Cope, 1883; Osborn, 1907; Gregory, 1922). The rate of this work has increased dramatically over the past few decades, with an emphasis on mammalian teeth as guides for chewing (e.g., Crompton and Sita-Lumsden, 1970; Kay and Hiiemae, 1974). Dental biomechanists have since viewed molar morphology in terms of mechanical efficiency for particular masticatory movements as the lower teeth come into and out of occlusion with corresponding uppers.

It was in this light that, more than a quarter century ago, Grine (1981) first observed differences between facet inclinations of different early hominins. He noted that *Australopithecus africanus* molars have steeper facets than do those of *Paranthropus robustus* (especially *P. robustus* from Swartkrans). The more inclined facets evinced by *A. africanus* suggested that these hominins engaged in more shearing, where facet faces slide past one another nearly parallel to their planes of contact. In contrast, *P. robustus* had less inclined facets, suggesting to Grine a shallower approach into and out of centric occlusion and more grinding activity (defined by both perpendicular and parallel components to occlusal contact). He proposed that this, along with other lines of evidence, such