5. Tooth wear and diversity in early hominid molars: A case study

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Abstract

Functional relationships between diet and tooth morphology form an integral part of paleontological research. The detailed description of occlusal relief and wear patterns of molars provides information about food ingestion and mastication. In early hominids overall molar morphology is fairly similar. Size measurements, such as buccolingual or mesiodistal diameter and 2-D cusp area of hominid molars show considerable overlap. The pioneering works of Butler, Mills, Hiiemae, Kay, Maier and others have shown that the wear pattern on the occlusal surface seems to reflect mastication behavior as an indication of diet. However, most of the interpretations are based on two-dimensional analyses. Occlusal relief measured in 3-D highlights functionally important

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features useful for quantifying the complex wear patterns on hominid teeth. However, until recently they could not be measured because techniques and methods were lacking. Nevertheless the results of 2-D analyses so far demonstrate that the occlusal surface of teeth records a significant part of the life history of an individual. The 3-D analysis of wear patterns on hominid teeth may provide additional information regarding the relationships between diet, chewing behavior and early hominid evolution. In this case study we employ a new 3-D approach to compare details on the occlusal surface of worn molars of *Australopithecus afarensis, Australopithecus africanus* and *Paranthropus robustus* in order to examine possible differences in tooth wear patterns. High resolution optical topometry enables us to measure parameters on 3-D computer models of teeth. Here, we compare various occlusal morphologies of worn lower second molars and attempt to interpret function, taking dental and masticatory principles into account. Our results indicate that diverse modes of occlusal wear in *Australopithecus* and *Paranthropus* are evident. A closer look at the occlusal relief and wear facet pattern shows that an assortment of mechanisms for crushing, shearing and grinding on a single tooth are common, since orientation and inclination of wear facets vary. The fact that *A. afarensis* molars show diverse functional areas with little variation among individuals suggests it had a dental toolkit to cope with a wide range of food qualities and may indicate a species-specific dietary spectrum. *A. africanus* and *P. robustus* molars, with their pronounced and relatively rapid flattening of crown relief and diverse individual wear patterns, point towards hard-object feeding and greater intraspecific variation in diet. *P. robustus*, however, with somewhat higher occlusal relief, can be interpreted as an omnivorous generalist with hard objects as fall-back foods.

Introduction

It is generally agreed that tooth wear in mammals is a result of the relationship between the upper and lower jaws, so that the resulting wear patterns yield information about both the mechanisms of food breakdown and the composition of the diet. Teeth are constructed and positioned for a close interaction between the antagonistic upper and lower dentitions. Thus, biomechanical constraints derived from tooth form and tooth size affect how food is prepared and which dietary items are selected. However, it has been hypothesized that tooth relief is adapted to species-specific diet as a compromise of phylogenetic preconditions and actual functional demands (Maier and Schneck, 1981, 1982).

In addition to tooth shape, jaw movement has an important influence on mastication and tooth wear. Previous studies showed that there are two major types of jaw action during the masticatory cycle (Crompton and Hiiemae, 1970; Hiiemae and Crompton, 1971; Hiiemae and Kay, 1972, 1973; Kay and Hiiemae, 1974). The masticatory cycle generally starts with puncture-crushing, in which tooth-tooth contact rarely occurs. Puncture-crushing generates blunting of cusp tips (Hiiemae and Kay, 1973) and the loss of tooth material during this action is caused mainly by abrasion or contact with the various foodstuffs (Stones, 1948; Kay and Hiiemae, 1974). Puncture-crushing generally results in wear areas with coarse surfaces, rather than wear facets that are clearly defined and circumscribed areas of polished enamel (Stones, 1948; Kay, 1977).

The puncture-crushing phase is followed by the chewing phase (Crompton and Hiiemae, 1970). It is during this second type of action (chewing) that tooth-tooth contact occurs more often. After food is sufficiently softened, the antagonistic teeth come into contact and the direction of jaw movement is guided by the crown morphology. During chewing, complementary edges and areas of the antagonistic lower and upper teeth, which form functional units, shear against each other and food is cut between pairs of edges and ground between facets (Maier and Schneck, 1981, 1982). Thus, foodstuffs are exposed to compression, traction, and shearing, depending on the crown relief.

The original or primary relief of the tooth crown is subsequently reshaped by these masticatory processes. Wear facets