6. 3-D interferometric microscopy applied to the study of buccal enamel microwear

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Abstract

Dental microwear analysis is based on the assumption that a correlation exists between ingested diet and microwear patterns on the enamel surface of teeth, such that diet can be reconstructed by quantifying enamel microwear. Abrasive particles, such as plant phytoliths or silica-based sands incorporated into food items, along with food processing techniques and tooth morphology, are responsible for the microwear features observed. Dental microwear has been extensively studied in both extant and extinct primates, including human populations. The dietary and ecological information that can be derived from dental microwear analyses makes it a technique useful for analyzing non-primate species, such as muskrats, sheep, bats, moles, antelopes, pigs and even dinosaurs. In the attempt to reconstruct species' ecology and diet, microwear research has become a successful procedure. The proliferation and persistence of different methods to quantify microwear patterns

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require very accurate definitions of microwear variables, since inter-observer error rates cannot be neglected. The use of semiautomatic methods to quantify microwear features does not guarantee low inter-observer error affecting dental microwear results. Error can be caused by taphonomy, microscopy drawbacks of back-scattered electrons, or differences in SEM reproducibility depending on sample shape and orientation. However, fully automatic procedures lack discrimination between ante-mortem and post-mortem wear processes that affect tooth enamel at various degrees, and their application requires experienced control and evaluation.

Introduction

Plant foods contain significant amounts of phytoliths in their tissues, such that dental microwear is directly related to ecological conditions and diet composition (Teaford, 1994; Ungar and Teaford, 1996; Ungar, 1998). Seeds, shoots, and inflorescence (Ball et al., 1996) are among the main food items that have an effect on enamel microwear (Danielson and Reinhard, 1998; Gügel et al., 2001), although food processing techniques can also influence enamel microwear by incorporating dust and ashes into the ingested foods (Teaford and Glander, 1991, 1996; Ungar, 1995; Daegling and Grine, 1999). In addition, tool technology plays also an important role (Teaford, 1991; Pérez-Pérez et al., 1994). It should be noted that diet-related variables do not affect dental enamel in isolation, but that gnathic morphology must also be taken into account (Gordon, 1982).

Dental microwear of both extinct and extant primates has been widely studied (Ryan, 1979; Gordon, 1982; Kay, 1987; Teaford and Runestad, 1992; Ungar, 1992, 1994, 1996; Ungar et al., 1995; King et al., 1999b; Galbany, 2004; Godfrey et al., 2004; Nystrom et al., 2004; Galbany et al., 2005b), including human populations (Grine, 1986; Lalueza and Pérez-Pérez, 1993; Lalueza et al., 1996; Martínez et al., 2004; Pérez-Pérez et al., 1999, 2003). Enamel microwear analysis has proven to be highly informative regarding dietary habits and paleoecology, and has been applied to a wide range of taxa, including muskrats (Lewis et al., 2000), sheep (Mainland, 2003), bats (Strait, 1993), moles (Silcox and Teaford, 2002), antelopes (Solounias and Hayek, 1993), pigs (Ward and Mainland, 1999), and suids (Hunter and Fortelius, 1994).

When attempting to reconstruct species' ecology and diet, dental microwear research has thus become a successful line of research. The first dental microwear papers were published in the 1950's (Butler, 1952; Mills, 1955), although no quantitative results were given. It was not until the 1980s that several authors proposed alternative methods to quantify microwear features (Gordon, 1982, 1984; Grine, 1986; Ungar et al., 1991, 1995). However, the persistence of an abundance of different methods to quantify microwear patterns greatly limits the comparison of results among researchers (Grine et al., 2002; Galbany, 2005a). Due to high inter-observer error rates, Grine et al. (2002) proposed the adoption of *Microware* 4.0 (by P. Ungar) as standard software for semi-automatic microwear analysis. Nevertheless, Galbany (2005a), using *Sigma Scan Pro* 5.0 (by SPSS) have shown that error rates are independent of the software used, but are highly dependent on how variables are defined and the researcher's expertise (Pérez-Pérez et al., 1999; Galbany et al., 2004b).

The use of semiautomatic methods does not guarantee reliability of results because various sources of measurement error persist, such as using back-scattered or secondary electrons in SEM observation (Pérez-Pérez et al., 2001; Galbany, et al., 2004b), varying the working distance, or any surface tilt. SEM images, which depend on the shape and orientation of the sample (Gordon, 1982; King et al., 1999b; Ungar, 2003), do not