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Research paper

Human enamel rod presents anisotropic nanotribological properties

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ABSTRACT

The AFM combined nanoindentation was performed to observe the ultrastructure of enamel rod from various section plans and positions while probing their mechanical and tribological properties of the area. The nanohardness and the elastic modulus of the head region of the enamel rods are significantly higher than that of the tail region and the axial-sectional plane. Both nanohardness and elastic modulus gradually decrease from enamel surface toward dentino-enamel junction. Such a variation correlates well with the decreasing trend of calcium composition from our element analysis. The friction coefficient and nanowear of the enamel showed an inversed trend to the hardness with respect to their relative topological position in the long axis of enamel rod toward DEJ. The relationship between the nanowear depth and the distance from the outer enamel surface to DEJ presented exponential function. The results presented clarify the basic nanomechanical and nanotribological properties of human enamel rods and provide a useful reference for the future development of dental restorative materials.

1. Introduction

Human teeth act as mechanical devices in cutting, incising, tearing and grinding food during the mastication process (Kishen et al., 2000). Teeth must have sufficient stiffness and wear resistance to maintain an effective mastication over lifetime. Thus, the protective enamel layer on the tooth crown is the hardest tissue found within the human body.

Biological materials generally exhibit hierarchical structures from the macro scale down to the nanoscale (Ji and Gao, 2004; Niu et al., 2009). The mineral phase of human enamel consists of hexagonal hydroxyapatite crystals approximately 68 nm long and 26 nm in diameter glued with each other by a 2 nm thin protein layer (Bres et al., 1986; Kerebel et al., 1979). Collectively, these crystals form enamel rods of 5-μm diameter keyhole-like structure in the coronal section

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