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The contact mechanics of nano-abrasion of dental enamel

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Tooth enamel plays a critical role in the survival of mammals despite its inability to repair, however the mechanisms responsible for its abrasive wear are poorly understood. Specifically, what factors in the diet of a mammal, especially their hardness and elastic modulus, contribute to enamel wear? In this study the stresses that develop during sliding contact of small spheres with enamel are evaluated. Knowing the stresses allows prediction of abrasive wear with an analytical wear model. For metals a brittle oxide film may be present, which influences the resultant abrasion mechanism. Stresses that develop during normal plus tangential loading, to simulate the coefficient of friction (CoF) developed during sliding are presented with and without a thin brittle film on the metal sphere. Three boundary conditions are assumed for sliding contact, namely; normal, lateral and tilting of the surface for three CoFs. The higher CoF is closest to that for a ductile metal (aluminium) in sliding contact with enamel. The CoF influences the magnitude and location of the maximum stress as does the tilting angle. Under normal and low CoF the maximum stress is located subsurface while at high CoF the maximum occurs at the surface and is up to 3 times greater than for the normal loading. Tilting also increases the surface stress concentration and it is no longer symmetrical about the axis of sliding. In the presence of a thin stiffer oxide film on the surface of the ball the maximum stresses occur at the edge of the area of contact and for normal loading are comparable to the max stresses subsurface but not within the enamel substrate. However, a slight increase in the CoF results in much higher stresses within the film. The influence of the specific boundary conditions on the magnitude of the stresses developed is also presented. These results are completely scale invariant and are thus of use for similar problems in thin film and multilayer applications.

Keywords
stress