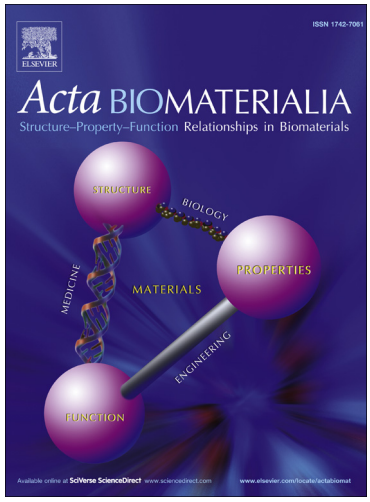

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Wear and Abrasion Resistance Selection Maps of Biological Materials

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ABSTRACT

The mechanical design of biological materials has generated widespread interest in recent years, providing many insights into their intriguing structure-property relationships. A critical characteristic of load-bearing materials, which is central to the survival of many species, is their wear and abrasion tolerance. In order to be fully functional, protective armours, dentitious structures, as well as dynamic appendages must be able to tolerate repetitive contact loads without significant loss of materials or internal damage. However, very little is known about this tribological performance. Using a contact mechanics framework, we have constructed materials selection charts that provide general predictions about the wear performance of biological materials as a function of their fundamental mechanical properties. One key assumption in constructing these selection charts is that abrasion tolerance is governed by the first irreversible damage at the contact point. The maps were generated using comprehensive data from the literature and encompass a wide range of materials from heavily-mineralized to fully-organic materials. Our analysis shows that the tolerance of biological materials against abrasion depends on contact geometry, which is ultimately correlated to environmental and selective pressures. Comparisons with experimental data from nanoindentation experiments are also drawn in order to verify our predictions. With the increasing amount of data available for biological materials also comes the challenge of selecting relevant model systems for bioinspired materials engineering. We suggest that these maps will guide this selection, by providing an overview of biological materials that are predicted to exhibit the best abrasion tolerance, which is of fundamental interest for a wide range of applications, for instance in restorative implants and protective devices.