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Research paper

Continuum damage model for bioresorbable magnesium alloy devices — Application to coronary stents

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ABSTRACT

The main drawback of a conventional stenting procedure is the high risk of restenosis. The idea of a stent that “disappears” after having fulfilled its mission is very intriguing and fascinating, since it can be expected that the stent mass decreases in time to allow the gradual transmission of the mechanical load to the surrounding tissues owing to controlled dissolution by corrosion. Magnesium and its alloys are appealing materials for designing biodegradable stents.

The objective of this work is to develop, in a finite element framework, a model of magnesium degradation that is able to predict the corrosion rate, thus providing a valuable tool for the design of bioresorbable stents. Continuum damage mechanics is suitable for modeling several damage mechanisms, including different types of corrosion. In this study, the damage is assumed to be the superposition of stress corrosion and uniform microgalvanic corrosion processes. The former describes the stress-mediated localization of the corrosion attack through a stress-dependent evolution law, while the latter affects the free surface of the material exposed to an aggressive environment. Comparisons with experimental tests show that the developed model can reproduce the behavior of different magnesium alloys subjected to static corrosion tests. The study shows that parameter identification for a correct calibration of the model response on the results of uniform and stress corrosion experimental tests is reachable. Moreover, three-dimensional stenting procedures accounting for interaction with the arterial vessel are simulated, and it is shown how the proposed modeling approach gives the possibility of accounting for the combined effects of an aggressive environment and mechanical loading.

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1. Introduction

In the last few years, research into biomedical applications has focused on bioresorbable materials. Biodegradable

devices can perform a specific function for a certain period of time and then gradually disappear, avoiding long-term complications, and progressively transfer the load to the surrounding tissue, inducing positive remodeling. Moreover,

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