A methodology for patient-specific simulation of the bone-healing process based on the Cartesian Grid Finite Element Method – cgFEM

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Biocompatible metallic implants are only temporarily required and, as indicated by the manufacturers, must be removed after its therapeutic service to prevent complications like breakage, corrosion, migration, growth restrictions in children, physiological and/or psychological reaction to the material, pain, further bone damage in case of accidents, interference with standard imaging techniques and stress shielding [1]. However, removing the implant requires a second surgical intervention that always involves psychological costs for the patient (and relatives) and financial costs for the patient and the health system. The use of biodegradable polymers (BPs) with high mechanical resistance, slow degradation and complete absorption properties could hold significant potential in the design of surgical devices for osteosynthesis. However, the use of BPs has not been yet generalized to major osseous surgery. Among other reasons, this is because *patient-specific* BP implant design methodologies need to be developed first. These design methodologies must be able to simulate the following simultaneous processes: a) bone remodelling, b) bone healing and c) BP degradation.

In this work we will present a numerical methodology developed for patient-specific bone healing process simulation. The methodology is based on the Cartesian Grid Finite Element Method (cgFEM) that is able to create patient-specific FE models directly from medical images [2]. The bone healing process implemented is based on fuzzy logic rules [3], showing a good correlation with experimental tests. The methodology developed can be used to perform *in-silico* simulations to analyse the effect of different parameters on the bone-healing process. In this sense, we will show several results that show that the proposed methodology represents a solid starting point for the development of a methodology for personalized BP-implant design but also of great help in the definition of more efficient treatments.

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