
Computational modelling of biodegradable bone implants

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Abstract

Bio-resorbable bone implants represent a recent advancement proposed for orthopedic surgery, as they have the capability of gradually dissolving while feeding the bone with nutrients which sustain its growth and remodeling. If properly designed, the degradation time of an implant can be tailored to match the parallel healing process of the bone, thus ideally eliminating the need for secondary removal surgery. Magnesium alloys have emerged as most promising constituent materials for orthopedic screws, given their proven balance between mechanical resistance and the effectiveness in providing essential nutrients to the surrounding tissue.

Modeling the simultaneous processes of implant degradation and bone healing is not a trivial task from a computational standpoint, not only since the boundary between the two changes over time but also because the grow-back feedback mechanism of the nurtured bone must be accounted for. To tackle these aspects, in the present work advanced techniques such as phase – field formulations and peridynamics have been employed, given their intrinsic proficiency in capturing evolving boundaries and non – local effects. These modeling approaches can also be linked to classical Finite Element formulations for the evaluation of the mechanical performance of the screw over time. The implemented modeling strategy aims at capturing the biological feedback mechanisms and mechanical environment, providing a comprehensive view of the implant's performance over time.

Preliminary results demonstrate the potential of Magnesium implants to support bone regeneration while maintaining structural integrity during degradation. These findings pave the way for further optimization and clinical application, highlighting the transformative potential of this technology in enhancing patient outcomes.

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