Abstract

Bone fractures and defects are common orthopedic issues that present significant global health challenges. These conditions can result from trauma, infections, osteoporosis, tumors, and other skeletal disorders, and impose a substantial economic burden. Moreover, surgeries for bone defects often encounter complications such as implant failure, infections, and metabolic disorders, which hinder effective bone healing. These issues can lead to delayed or non-healing fractures, decreasing patients' quality of life and increasing healthcare costs.

This project proposes the use of biodegradable Zn-based alloys for bone repair surgeries, as an alternative to traditional materials (e.g. titanium and stainless steel), which show limited success in patients with disrupted bone metabolism. Specifically, Zn-Mg alloys offer the potential for dual benefits: providing mechanical support and promoting biological healing. However, these alloys currently face challenges, including low tensile and compressive strength, and their performance in clinical settings is influenced by the complex physiological environment. Further research is, thus, required to optimize their properties for specific clinical applications.

The aim of this project is to investigate the impact of different surface treatments—laser surface texturing and surface mechanical attrition—on an optimized Zn-Mg alloy to improve bone metabolism and healing in individuals with impaired bone regeneration. Special attention will be given to the structure-property-function relationships of the material surface at various scales with consequences on cell-material interaction. This interaction is modulated by surface chemistry, mechanical properties, and topography, requiring interdisciplinary research across nano- and micro-scales. The consortium employs a range of characterization techniques to link surface properties, biological reactivity, and cellular behavior, with in vitro, ex vivo, and in vivo experiments planned to support clinical translation.