

Abstract

Orthopaedic Implant Design and Computational Simulation

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Orthopaedics implants are devices implanted into patients in order to aid the repair of damaged or fractured bones, or to replace part of a diseased joint such as the hip or knee. The primary goal of an orthopaedic procedure is to restore functionality of the bone or joint for the patient, and relies on the selection of the appropriate implant type, size, the surgical procedure used to implant the device, and how the device interacts with the patient's bone once it is in place. Although the basic concept of many of the orthopaedic devices in clinical use today were originally developed many decades ago (e.g. hip stems, sliding hip screws, plates and screws), further research and development (R&D) is ongoing in areas such as implant material properties, surface features, screw configurations, as well as new implant designs.

Orthopaedic technology R&D involves a significant amount of testing. Lab based testing of implants in cadaver bones is costly and subject to the inherent variability of bone shapes, sizes and strength from one patient to another, meaning for example, that two implants cannot be tested and compared in exactly the same bone. In more recent years, the use of plastic femurs has greatly aided experimental testing but the range of bone types and materials is limited. For these reasons, the use of computational modelling is an important tool in orthopaedic implant design process. It allows the virtual simulation of multiple implants in the exact same bone and loading configuration. In parallel, advances in imaging hardware (e.g. CT, MRI, X-ray) and 3D image reconstruction software (e.g. Mimics, ScanIP) has allowed high resolution patient specific geometry and material property distribution to be incorporated into the FE models. In this project the commercial finite element (FE) code Abaqus (DS SIMULIA, USA) will be used to construct and analyse advanced models of bones with novel orthopaedic implants addressing current clinical needs. Specifically, the research will focus on:

- Implant design for joint replacement (direct load bearing implants)
- Micro-scale surface features for immediate and long term bone engagement
- Improved implant elastic modulus matching with the host bone
- Implant design for fractured bones (load sharing implants)
- Optimising the number of and orientation of screws in fracture fixation devices
- Modelling of implant loading in 3D dynamic gait simulations