MONASH
ENGINEERING

MONASH University

Faculty of Engineering
Summer Research Program 2024-2025

Project Title: Early detection of osseointegrated implant loosening

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Objective

Stress shielding is recognised as a major contributor to implant loosening. Bone is living tissue in a continuous remodelling process in response to biological and mechanical stimuli. Trans-femoral osseointegrated implants alter the load path through the residual femoral bone of an amputee relative to that in the intact bone. This project will investigate the use of a suitable scalar parameter to quantify the mechanical stimulus to simulate the bone remodelling process. The aim is to understand the effects of this bone remodelling on the contact conditions at the bone/implant interface and its eventual loosening.

Project Details

The project will include investigate the use of the octahedral shear stress as the scalar parameter to quantify the mechanical stimulus, in accordance with a recent experimental study showing better agreement with laboratory observations of bone remodelling in rat tibiae relative to the more widely used Stanford model that employs strain energy density instead. The bone-implant interface will be modelled by a surface-to-surface contact law relating the tractions at the interface to the relative displacements across the interface, instead of the more common choice of a perfect contact interface, which precludes the modelling of implant loosening. This contact law is based on the principles of continuum damage mechanics, with the added twist that the damage parameter is allowed to be negative, to describe the consolidation phase during the early stages of osseointegration. Given these uncertainties with the modelling, a systematic approach requires a sensitivity analysis to assess the influence of various modelling assumptions and parameters. Sensitivity analyses will therefore be included in the research plans.

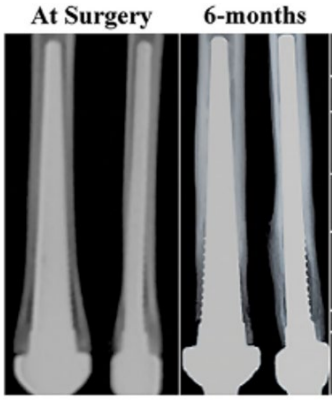

Fig. 1: Serial radiographs taken at surgery and 6-months later, showing bone loss due to shielding.

Prerequisites

Completed MEC3455 and MEC3453.

Additional Information

Submit as a word document - no more than one page long.