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FINITE-ELEMENT ANALYSIS AND EXPERIMENTAL INVESTIGATION OF GROOVED AND POROUS COLLAR IN INDUCING EXTRA-CORTICAL BONE GROWTH FOR MECHANICAL FIXATION

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The successful osteointegration of massive prostheses to treat bone cancers is critical to ensure their long-term survival, but mechanical fixation among patients is difficult to predict [1]. The use of a hydroxyapatite-coated grooved collar has been demonstrated to encourage extra-cortical bone formation, improve fixation and implant survival [2]. It is hypothesized that the use of porous collars could provide a better scaffold for bone ingrowth. There is a need to develop computational tools for optimizing the design of porous collars, reducing the requirement for pre-clinical testing in animals.

The geometry and material properties from two ovine tibiae were obtained from computed tomography (CT) scans and used to develop Finite Element (FE) models of the tibiae implanted with different collar designs. The bones were assigned inhomogeneous, transversely isotropic material properties based on the CT grey values and typical walking load conditions were applied. A bone remodeling algorithm based on strain energy density combined with a new concept of bone connectivity was used as the bone adaptation criteria, where the rate of bone adaptation is controlled by the difference in the current strain energy against the reference value [3]. The bone adaption results for the grooved collar designs were first verified against experimental studies at different time stages and shown to match the process of bone growth (Figure 1). Thereafter, the bone formation process for the porous collar was predicted before an experimental study was undertaken to verify the computational results. This computational tool thus shows potential to be developed further for the optimization of collar designs.

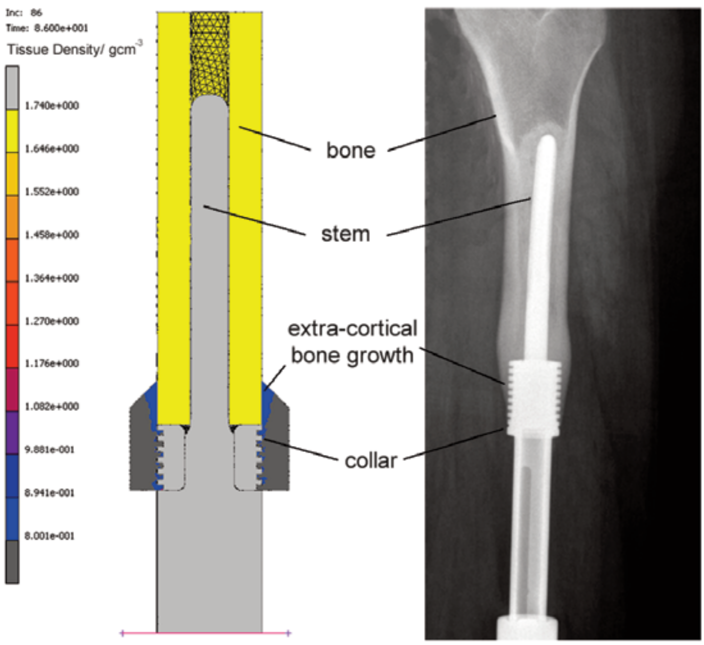

Figure 1: The bone modeling results (left) showing good correspondence with X-ray images (right) of hydroxyapatite collar with good osteointegration taken 12 years after implantation.

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References:

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