Bone Remodelling Following Total Hip Replacement: Short Stem Versus Long Stem Implants

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Abstract

Bone resorption around hip stems, in particular periprosthetic bone loss, is a common observation post-operatively. A number of factors influence the amount of bone loss over time and the mechanical environment following total hip replacement (THR) is important. Conventional long stem prostheses have been shown to transfer loads distally, resulting in bone loss of the proximal femur. More conservative, short stems have been recently introduced to attempt to better replicate the physiological load distribution in the femur. The aim of this study was to evaluate the bone mineral density (BMD) change over time, in a femur implanted with either a short or a long stem. COMSOL Multiphysics was used to simulate bone remodeling under a physiological load condition (20% gait) when a short (Minihip, Corin, UK) and a long (Metafix, Corin, UK) hip stem where implanted in a patient specific femur. The magnitudes and directions of the muscle forces and joint reaction force were obtained from literature [Heller et al. 2005]. A strain-adaptive remodeling theory was utilized to simulate remodeling in the bone after virtual implantation, where the strain energy density per unit mass of the implanted models were compared to that of a intact (unimplanted) femur model. A minimal inhibitory signal [Frost 1964], was implemented in the bone remodeling algorithm and described by a 'lazy zone', where no bone remodeling occurred. The overall percentage BMD change observed after 2 years of implantation showed that long stem design disrupts the mechanical environment more than short stems, and this lead to a greater bone mineral reduction over time. (Acknowledgment: The authors acknowledge the support of the TSB in providing funding for this research).

Figures used in the abstract

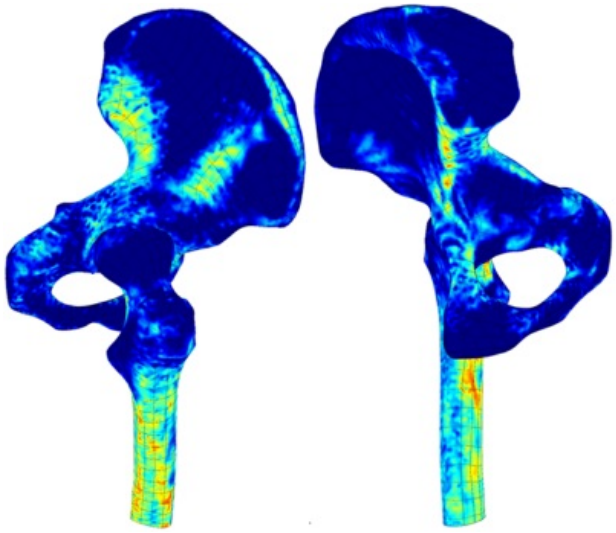

Figure 1: Patient specific pelvis & femur model illustrating density mapping obtained from CT-Scans.

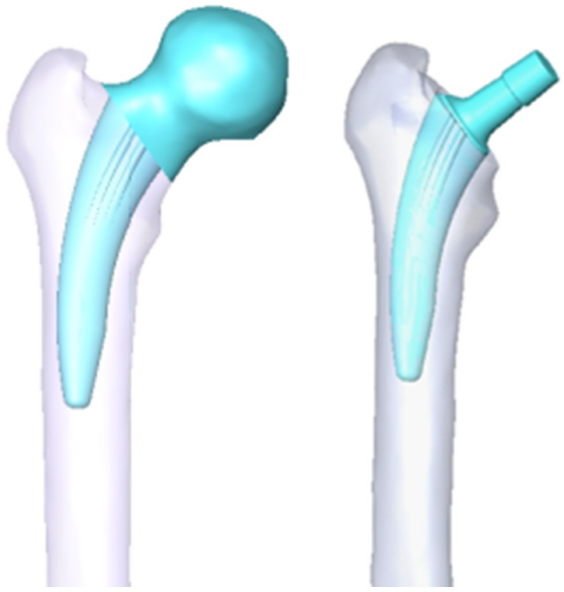

Figure 2: Comparison of intact & implanted models illustrating common interface.

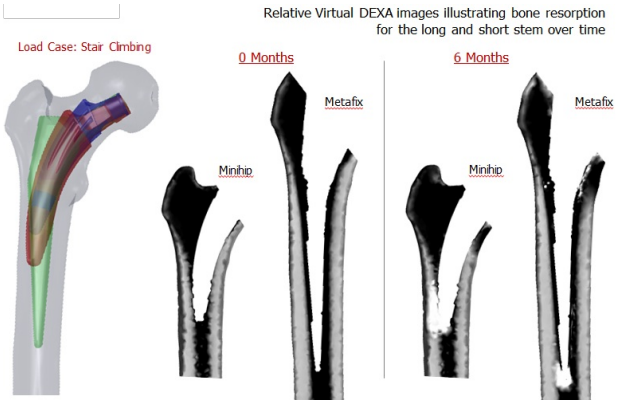

Figure 3: Image illustrating relative position of short & long stem implants & Virtual DEXA images showing bone resorption for the long and short stem after 6 months