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A Study of Strain Related Bone Remodelling of the Osseointegrated Patient

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INTRODUCTION: Osseointegrated trans-femoral implant is a novel anchoring orthopaedic method for connecting the bone of stump and the prosthesis. Compared to the stump-socket prosthetic limb attachment, this technique shows advantages in overcoming problems of soft tissue damage, artificial limb control and constraint limb fitting for difficult stumps [1]. Long-term X-ray images (Figure 1 a) of osseointegrated patients show obvious bone remodelling phenomenon (bone loss and bone growth). This study outlines a reconstruction method of intact and adapted femur-implants (Figure 1 b), using a UK osseointegration patient's X-ray image and CT scans. The relationship between bone remodelling and strain distribution of the femur was found based on Finite Element (FE) analysis.

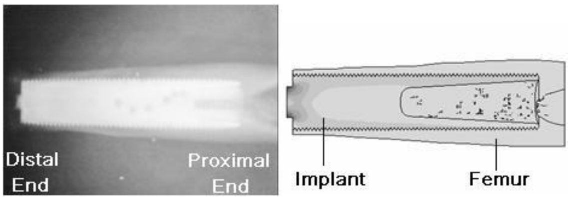
METHODS: According to previous work [2], a Canny edge detection method was applied for detecting the bone edges on pre-surgery CT images of the femoral cross-section. Using a customized MATLAB femur generation programme, a three-dimensional intact femoral diaphysis model was constructed by stacking those coordinate edge profiles in the sequence of the CT scans.

The long-term X-ray images were used to measure the bone wall thickness change. The values were integrated into the femur generating programme for generating an adapted (after 31 months) femur model.

The implant model was inserted into the femoral models by a Boolean operation. A body weight associated load case of the patient was applied to the femur-implant models. The FE package ABAQUS was used to carry out the FE analysis and von Mises equivalent strain distributions in intact and adapted models were calculated and compared to each other.

RESULTS:

Figure 2 plots the von Mises equivalent strain distribution along the lateral side of the femur-implant models from the distal end to the proximal end for the intact model (0 month) and the adapted model (31 months).



(a) (b)

Fig.1: Section views of X-ray image of adaptive femur-implant system (a) and reconstructed femur-implant computer model (b).

Compared to the 0 month model, the strain level of the 31 month model increased around distal end and decreased around proximal end. Within the middle region, there was no significant change between these two models.

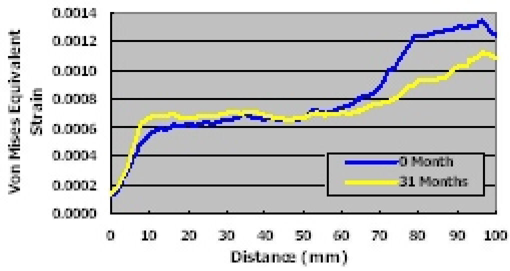


Fig. 2: von Mises equivalent strain distribution along lateral side of intact and adapted models from distal end to proximal end

DISCUSSION & CONCLUSIONS: The general consensus is that the bone can adapt its structure according to a change in the stresses, which the bone tissues experience [3-4]. In this study, the FE simulation shows the strain distribution approaches the strain level where around the middle region of the model after 31 months bone remodelling. It can be concluded that implanted femur tend to adapt to a uniform the strain distribution by bone modelling process.

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