BIORESORBABLE LATTICE WEDGE FOR PATIENT SPECIFIC TIME DEPENDANT STIFFNESS IN HIGH TIBIAL OSTEOTOMY FIXATION

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Introduction

A high tibial osteotomy (HTO) is an effective joint preserving surgery in cases of medial knee osteoarthritis, delaying the need for a total knee replacement by 10 years in 79% of cases [1]. Whilst effective, current HTO fixation methods come with some clinical problems: 41% of patients report discomfort due to large plate profile [2]; current fixation plates are too stiff, resulting in diminished bone healing capacity short term [3] and stress shielding long term; and up to a quarter of all HTOs are complicated by re-fracture at the lateral hinge [4]. It is argued these problems arise due to the one-size-fits-all approach of existing HTO fixation devices, recent efforts to address this limitation employ additive manufacture (AM) to create patient-specific devices [5]. To combat these problems the authors propose a novel concept: an additively manufactured bioresorbable lattice wedge, the design of which can be adjusted for patient-specificity, to stabilise the fracture from within the osteotomy. This allows for use of a smaller low-profile plate (Figure 1) and will reduce stress shielding as the lattice wedge is resorbed and replaced by the new bone.

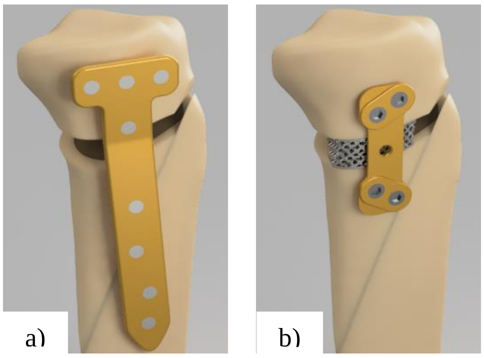

Figure 1: a) Gold standard T-plate, b) Small plate design with bioresorbable lattice shown in wedge gap

Methods

A bioresorbable lattice allows for the overall stiffness of the fracture fixation device to reduce over time. Zinc was chosen for its favourable mechanical properties and degradation rate when compared to other metallic bioresorbable materials. The initial stiffness and rate of change of stiffness can be controlled through variation of the initial lattice design, for example body centred cubic (BCC) or face centred cubic (FCC), exemplified in Figure 2. Homogenisation was used to simplify the simulation of the lattice within ABAQUS.

Sawbones model 3401-1 with 10 degree varus was used to conduct the HTO virtually. A finite element model of the HTO construct was created in Ansys using the gold standard T-plate (Figure 1a) and validated by comparing its performance to experimental values found in literature. The performance of the novel bioresorbable lattice fixation concept can now be tested within the validated construct.

Results

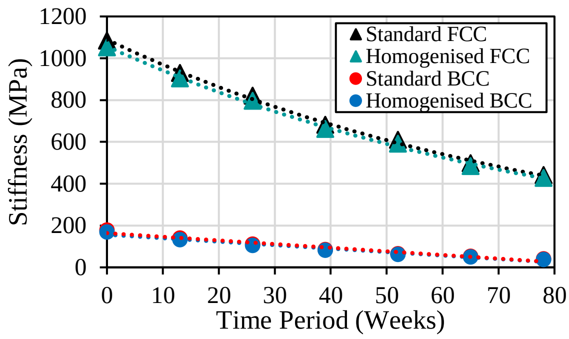

Figure 2: A graph showing a reduction in stiffness in zinc FCC and BCC lattices over a 78 week period (resorption rates taken from literature)

Figure 2 shows that lattice stiffness reduces over time as zinc material is resorbed by the body and that different lattice designs achieve different stiffness. Homogenised simplifications agree with standard lattice models.

Discussion

The bioresorbable lattice wedge allows for tailored stiffness variation during the fracture healing period. This provides stability short term but also reduces stress shielding long term when compared to the gold standard T-plate. In addition this allows for the use of a smaller fixation plate, which mitigates the problem of patient discomfort and helps to avoid revision surgeries.

References

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