STABILITY OF AUGMENTED TOTAL KNEE REPLACEMENT

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INTRODUCTION: An effective approach and an understanding of proximal tibial defects are very important for the survival of the tibial prosthesis after total knee arthroplasty. A Type-II defect of 10 mm depth was considered for this study. The defect was treated with four different combinations using block and wedge augments constructed from metal or cement. These were compared with a non-augmented Total Knee Replacement (TKR) model. The aim of this finite element (FE) study was to examine the effect of different augmentation options on bone with respect to clinical studies, which showed that when cement is used to fill tibial defects there tends to be a higher failure rate. [1-2]

MATERIALS AND METHODS: The 3D models for the FE study were constructed from a set of CT-scan dataset using image processing software SIMPLEWARE v3.2. The FE analysis was performed with ABAQUS v8.1. The material properties described in a previous 2D study [2] were used, and Figure 1 shows the various components in the Metal Block Augmented (MBA) TKR model. The model was fixed at the bottom of the cortical shell in all directions. A pressure load of 17.4 MPa was applied on both the medial and lateral condylar surfaces to give an axial load of about 3600N which is approximately four times body weight of 90kg person. [3-4].

Fig. 1: TKR-MBA model shows various parts of the assembly using a section cut.

RESULTS: Figure 2 shows the von Mises stresses in the TKR and the two block augmented models. On the augmented side the cancellous bone experiences a high stress around the periphery in the augmented models. Also on this side the overall level of stress seems to be higher in the Cement Block Augmented (CBA) TKR model followed by MBA-TKR model and finally the non-augmented TKR model. The trend on the non-augmented side is different with the augmented models tending to produce larger zones of lower stress (increased stress shielding) and also having slightly lower stresses around the periphery. Similar trends were identified with the wedge augmented model.

Fig. 2: Contour plot of the von-Mises stresses in the cancellous bone of a) TKR b) TKR-MBA and c) TKR-CBA.

DISCUSSION & CONCLUSIONS: The cancellous bone shows higher and more widespread stress near the bone cement interface on the augmented side in the CBA compared to the TKR and MBA models. A similar pattern was found with the Cement (CWA) and Metal (MWA) wedge augmented models. Whilst it could be argued that this higher stress in the cement augments might promote bone growth it would seem from clinical observations that the stresses may be too high. Taking the TKR model as a reference it can be concluded that both forms of augmentation produce conditions that could be less favourable for implant stability.