The Importance of a Good Cement Mantle with an All-Poly Inlay UKA

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Introduction: Patient and implant selection, surgical techniques, and the accuracy of unicompartmental knee arthroplasty (UKA) have improved since its initial introduction. Inlay UKA in which the tibial implant is inserted into a sculpted pocket on the tibial plateau has emerged as an intriguing alternative to traditional onlay UKA with the advent of improved instrumentation and robotic assistance (Figure 1).

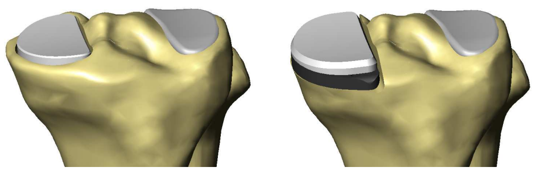

Figure 1. Tibia prepared with an inlay tibial component (left) and an onlay tibial component (right).

The thinner, peg-less inlay preserves the medial tibial cortex, potentially reducing patient pain and recovery time, and allowing easier revision to TKA if necessary. Though uncommon, early inlay failures generally show a similar theme of a thin or nonuniform cement mantle on post-op x-rays. The goal of this study was to examine the effect of cement penetration on cancellous bone and cement stresses, as well as implant/cement interface strains.

Materials and Methods: A 3D finite element tibia model consisting of a cortical shell, cancellous bone of varying properties, and 1mm of cement penetration was created (Figure 2).[1,2] A CoCr femoral component was centered on an all-poly inlay placed within a virtually prepared bone pocket.

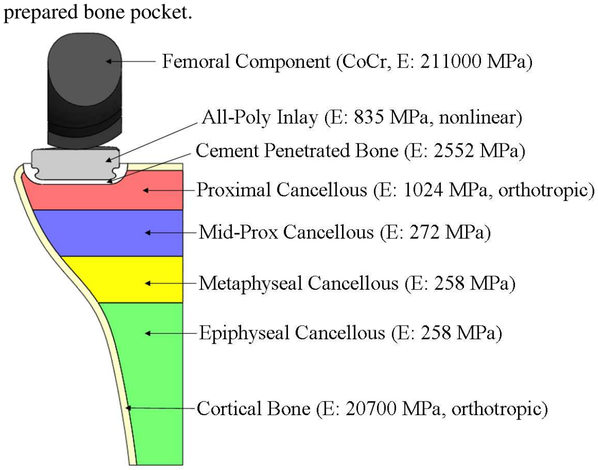

Figure 2. Cross-sectional view of simulated FEA model with the assigned material properties.

The model was meshed with tetrahedral elements varying in size from 0.5 to 3.0mm depending on area of interest. The distal tibia was fixed and the bone was assumed symmetric about the mid-sagittal plane of the tibia. The femoral component was loaded to 2100N (60% of a total joint load of 4.5xBW) inferiorly.[3] Maximum von Mises stresses in the cancellous bone, cement and UHMWPE were recorded, as well as the maximum von Mises strain at the poly-cement interface. Analyses were repeated with 2 and 3mm of penetrated cement, and then again with a 1400N medially-offset load.

Results: The volume of increased stress in the cancellous bone was immediately apparent from the results (Figure 3). Increasing cement mantle thickness with the MCK inlay significantly reduced von Mises stresses in the cancellous bone below the mantle. The 2mm mantle reduced cancellous stresses 15% compared to the 1mm mantle (5.8 MPa vs. 6.8 MPa). The 3mm mantle further reduced stresses to 4.9 MPa (28% less than the 1mm case).

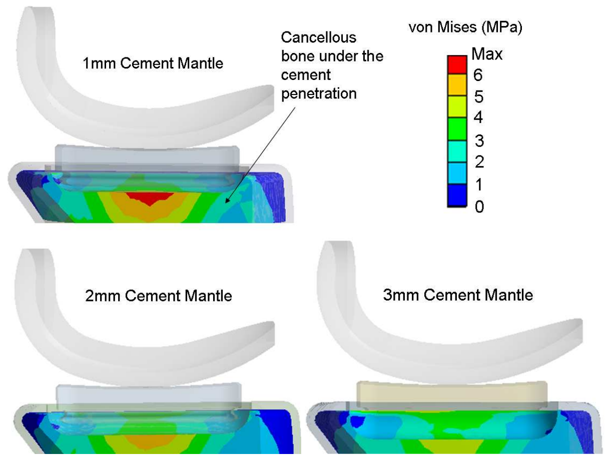

Figure 3. Medial cross-sectional view of the von Mises stresses in the cancellous bone below the cement mantle. Areas of high cancellous stress (red and orange) diminish with increasing cement penetration.

The maximum stress in the cement itself was also significantly reduced with a thicker cement mantle. Increasing cement thickness from 1mm to 2mm and 3mm, stresses in the cement fell 10% and 21%, respectively (Figure 4). Although not as significant, von Mises strains in the polyethylene at the cement interface also fell with increasing mantle thickness (1mm: 1.0%; 2mm: 0.97%; 3mm: 0.93%).

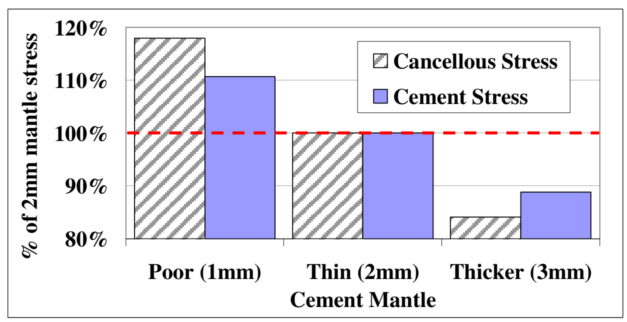

Figure 4. Percentage of cancellous bone and cement stresses under neutral loading relative to the case with 2mm of penetrated cement.

Under a 1400N medially-offset load, the importance of a good mantle was even greater. Cancellous stresses were reduced from 14.3 MPa with 1mm of cement to 9.0 MPa (37% reduction) and 6.0 MPa (58% reduction) with 2 and 3mm cement mantles, respectively. Similar reductions were seen in cement stresses (49% and 60% with 2 and 3mm of cement penetration).

Conlusions: Increasing cement mantle thickness for UKA inlay procedures has been shown to significantly decrease stresses in the cement and cancellous bone, and strains at the polyethylene/cement interface, potentially reducing patient pain, implant subsidence, risk of cement fracture, and the likelihood of implant loosening.

Careful preparation of the underlying bone bed, including fatty deposit removal via a modified pulse lavage and manual cement pressurization, is recommended to increase cement penetration and reduce the risk of early inlay failure.

References:

1. Lancianese SL et al. Bone. 2008 Dec
2. Khodadadyan-Klostermann C et al. Clin Biomech 2004 May
3. Morra EA et al. J Bone Joint Surg Am. 2008 Nov