

THERMAL PROPERTY DETERMINATION OF EMU CANCELLOUS BONE USING FINITE ELEMENT MODELING

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INTRODUCTION:

Osteonecrotic lesions created by cryoinsult in the emu model of femoral head osteonecrosis are dependent on the characteristics of the intra-operative thermal insult delivered. There is some debate as to the mechanism of cell death during cryoinsult. To elucidate the effects of a freeze on the cancellous bone in the emu femoral head, a thermal finite element model has been developed to study individual cryoinsults delivered intra-operatively to the cancellous bone of the emu femoral head. Because there are no data on the thermal properties of emu cancellous bone, a finite element model was created to reproduce experimental *in vitro* freeze conditions in an emu femur.

METHODS:

A 2D axisymmetric finite element model based on the cryoprobe position in the femoral head during an intra-operative cryoinsult procedure was developed in PATRAN and run in ABAQUS to model cryoinsult to emu cancellous bone (Fig 1&2).

Experimental freezes were performed in 4 cadaver emu femurs. In addition to thermocouples on the probe tip and shaft, 4 additional thermocouples were embedded in the femoral head at various distances from the cryoprobe, to measure temperature in the bone throughout a freeze and thaw. Temperatures obtained from the tip thermocouple during the physical testing were applied as a heat sink to the nodes at the tip of the cryoprobe.

Thermal conductivity and specific heat were prescribed as temperature-dependent thermal

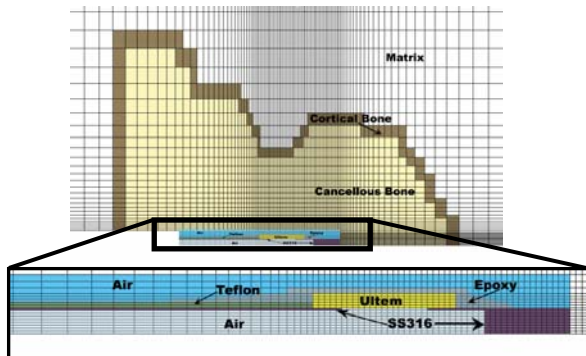


Figure 1. FE mesh is 2D and axisymmetric, consisting of 5550 nodes and 5390 elements (DCAX4).

properties, which varied based on state of the bone (frozen, unfrozen, transition). The nodes of the matrix were constrained to room temperature. Thermal property values were initially based on literature values for mammalian bone and were modified to bring the results from the FE model into agreement with experimentally measured temperatures. Nodes corresponding to an error envelope extending 1mm around the experimentally measured thermocouple location node were monitored (Fig 3).

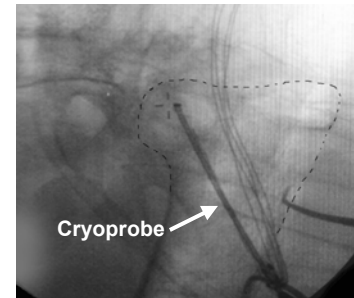


Figure 2. Intra-operative fluoroscope image of cryoprobe insertion into the femoral head. The dashed line assists in visualization of the proximal femur.

RESULTS & DISCUSSION:

The finite element model, with its emu-specific thermal properties, is used to model intra-operative cryoinsults. Temperature information from the FE model of intra-operative cryoinsults can be correlated with zones of histologically apparent necrosis in order to help explain the mechanism of osteocyte death during a cryoinsult.

REFERENCES:

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ACKNOWLEDGEMENTS:

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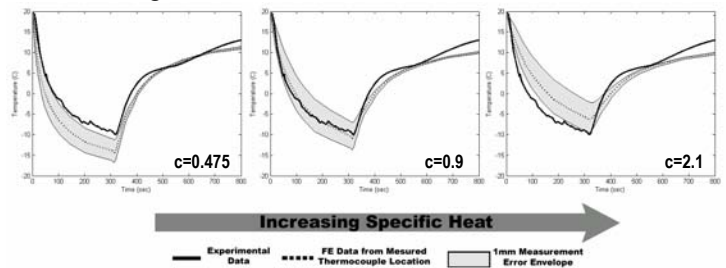


Figure 3. Effect of specific heat variations on FE temperature values at a single thermocouple and relationship to experimentally measured temperatures. Because specific heat is treated as a temperature-dependent property in the model, the above values of specific heat (c) are averages over the range of temperatures calculated in the model.