A computational knee model to study the development of osteoarthrosis in the knee joint

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Osteoarthritis can be defined as mechanically induced thickness loss of the articular cartilage with thickening and eburnation of the underlying bone. This means that during OA, changes in both the articular cartilage and the bone underlying the articular cartilage occur. The question is whether these changes occur independently or that one occurs as a result of the other. In this project we want to verify if articular cartilage damage and degeneration could cause densification of the underlying bone and to verify if densification of the bone underlying the articular cartilage could cause cartilage damage.

For this purpose an axisymmetric finite element model of the human knee joint was developed. In this model we included the articular cartilage layers of both the tibia plateau and the femoral condyle, the meniscus and the bone of the proximal part of the tibia. Both the articular cartilage and the meniscus were modeled as biphasic materials, including void-ratio dependent permeability. The articular cartilage was constructed of four different isotropic layers (superficial zone, transitional zone, radial zone and zone of calcified cartilage). The meniscus was modeled as transverse isotropic. The contact between the meniscus and the two cartilage layers was modeled as frictionless. Published information on forces in the knee during gait was used for dynamic loading data. To our knowledge the combination of all these features have not been presented earlier.

In figures 1 and 2 the pore pressure and von-Mises stress in the articular cartilage during heel strike are given.

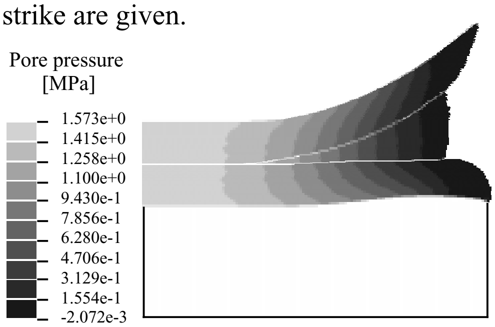

Figure 1: Pore pressure in the articular cartilage and meniscus during heel strike of the 15th gait cycle.

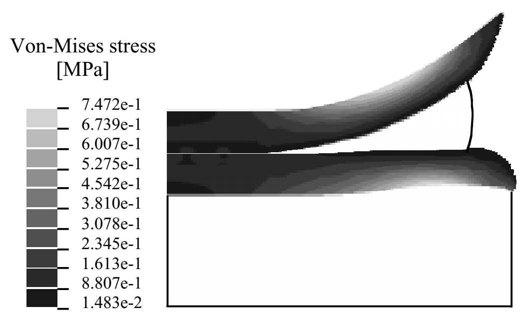

Figure 2: Von-Mises stress in the articular cartilage during heel strike of the 15th gait cycle.

The sites with the highest shear stresses as found with our finite element analysis, corresponded very well with the sites were cartilage damage is found after impact loading (Atkinson et al., 1995). The locations of the sites with the highest shear stresses also correspond with the numerical findings of Garcia et al. (1998) and Donzelli et al. (1999).

The finite element model seems to give realistic results and to be suitable to predict sites of cartilage damage accurately.

References

Atkinson et al., J. Orthop. Res. **12**:936-944 (1995)

Donzelli et al., J. Biomech. **32**:1037-47 (1999)

Garcia et al, J. of Biomech. Eng. **120**:608-613 (1998)