In-vivo assessment of patellofemoral joint stress using a finite-element analysis approach.

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Introduction

- Osteoarthritis of the patellofemoral joint is very common and has been reported in up to 25% of the population.
- Early intervention and/or prevention is crucial to minimize pain and pathology.
- Cause is believed to be stimulation of pain receptors from high stresses in the cartilage
- Finite-element modeling of the patellofemoral joint is thought to be an accurate way to calculate the stress distribution and the maximum stress in the patellar cartilage.[2]

Methods

- High-resolution images were obtained from a subject with patellofemoral pain. These images were taken with the knee joint at 0° flexion under no loading.
- Low-resolution loaded MR images of the subject's knee were obtained with the knee at 0, 30, and 60 degrees flexion.
- Sliceomatic software package was used to manually segment each sagittal slice of the components, as can be seen in Figure 1.
- The geometry was read with Hypermesh software, which was then used to create a model that could be used in Abaqus. Figure 2 shows a picture of a model of the joint.
- The bones were modeled as rigid bodies, while the cartilage was modeled as linearly elastic with an elastic modulus of 6.0 MPa and a Poisson's ration of 0.47.
- Quadriceps forces and directions are modeled based on inverse dynamics analysis, EMG measurements, and lines of action of each of the quadriceps muscles.
- The simulation is currently being refined, and is aimed at producing a stress distribution similar to that shown in Figure 3.

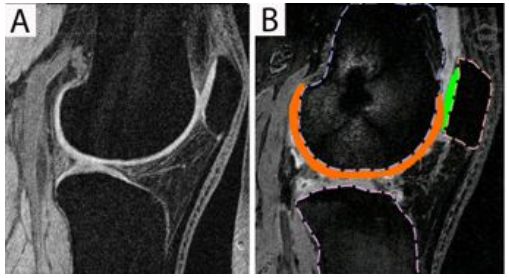

Figure 1: Segmented Saggital Slice

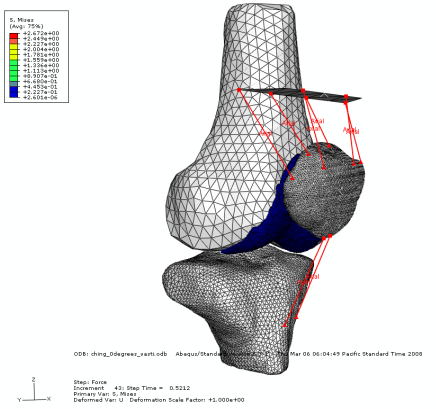

Figure 2: Hypermesh Model of the Knee Joint at 0° Flexion.

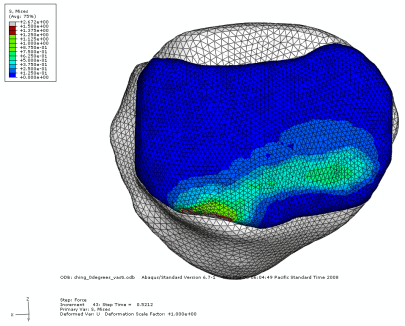

Figure 3: Example of Stress Distribution in the Patellar Cartilage.

Results

- Successful creation and positioning of the meshes was accomplished, although work remains to be done in calculating the quadriceps forces and directions in order to accurately produce an appropriately accurate stress distribution in the cartilage.

Discussion

- Repeatability and reliability of the segmentation and mesh creation is crucial and is best handled by a single researcher.
- Sensitivity analysis needs to be done to determine the largest meshes that can be used to accurately determine cartilage stresses, as computation time for a single model can be lengthy.
- Further research aimed at producing accurate subject-specific models could eventually be used to develop interventions for current patients with patellofemoral pain by modeling various effects of exercises that strengthen certain regions of the quadriceps that will change the stress distribution and lower the maximum stress experienced by the cartilage. It also could be used to identify individuals in which patellofemoral pain is likely to occur and identify recommendations for preventative medicine in this area.

References

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