Patient Specific Prognosis of Disease Progression in OA

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Introduction
Osteoarthritis (OA) involves articular cartilage degeneration. Because cartilage has limited repair capacity, earlier intervention will improve long-term clinical outcome. To select a suitable patient specific treatment, it is important to know whether for a particular patient, OA progression will be aggressive or mild (Figure 1). [1]

Figure 1: Normal knee and Knee with OA.

Aim
We set out to develop a tool that can assist in making such difficult prognostic evaluations.

Hypothesis
The premise is that mechanical loading importantly determines OA progression. Excessive mechanical stimulation causes cartilage wear and unfortunate load transfer between bone and cartilage induces sclerosis and osteophyte formation. These changes may result in a new equilibrium, or accelerate progression of OA.

Approach
In order to reach our goal we follow two lines:

1. Developing OA progression simulation model:
Describing damage in our validated cartilage model.

2. Selection, collection and transfer of clinical data:
Processing clinical data, in particular MR images, into a format that can be used as model inputs. (Figure 2)

Continuum Damage Mechanics
The basic premise of continuum damage mechanics is that microstructural damage can be characterised by continuum field variables: $D$ ($0 \leq D \leq 1$). In our model, damage evolves in a linear softening manner as a function of the straining it has undergone (Figure 3). [2]

Figure 3: Damage evolution: linear softening ($\kappa$ is a history parameter.).

Cartilage Model and Results
We modeled the cartilage as a 3D porous disk. We applied load on the disk cartilage by two methods, unconfined compression and indenter compression, and then compared the results of the two model for the distribution of Mises stress, damage and pore pressure (Figures 4, 5).

Figure 4: Unconfined compression: a) Mises stress b) Damage variable ($D$) c) Pore pressure.

Figure 5: Indenter compression: a) Mises stress b) Damage variable ($D$) c) Pore pressure.

Discussion and Future Work
Indentation loading can be related to OA status; since in OA the knee losses its normal load distribution so in some regions the load would concentrate locally and damage initiates. We plan to validate these results experimentally.

References