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Presentation Abstract

Session: Thursday General Poster Session

Presentation: Mixed Porohyperelastic Transport Finite Element Model with Chemically-Driven Growth

Presentation Time: Thursday, Jul 10, 2014, 9:00 AM - 5:00 PM

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Abstract: *Introduction:*
Most growth models for soft tissue assume that soft tissue deforms as a purely elastic material. However, biological tissues are saturated with fluid that bears part of the load, reducing the amount of deformation in response to stress. Our previous research has modeled the complex response of soft tissue using a one-dimensional, large-strain mixed porohyperelastic transport and swelling (MPHETS) finite element model with mechanically-driven growth [1]. The purpose of the current model is to build upon our previous work and incorporate chemically-driven growth into a simplified MPHETS growth model.

Methods:
We assume that growth occurs over a long period (weeks to months) while the response of the deformable and compressible porous media (e.g., consolidation) is on the order of minutes. In this initial approach we assume that growth only depends on the concentration of a mobile neutral species (through a local chemical potential) and is independent of tissue deformation. For initial small strain demonstration purposes, we fix the right side of the one-dimensional domain and apply a total stress and a pore fluid pressure to the left side, as shown in Figure 1A. A chemical potential gradient is also applied across the domain, with a higher value on the left.

Results:
Figure 1B shows the MPHETS steady-state solution as well as the grown solution for mechanically-driven growth [1]. Note that a higher positive displacement corresponds to increased compression and thus material resorption. Figures 1C and 1D show the solution for chemically-driven growth.

Discussion:
For the mechanically-driven case, growth based on stress causes the material points to displace even further than expected from compression alone due to material resorption. For chemically-driven growth, the positive chemical concentration causes growth that counteracts material compression, as seen in Figure 1C. Figure 1D shows that tissue growth exhibits a dose response; the arrow denotes increasing growth from higher concentration values after an arbitrary growth time. The gradient in chemical potential causes more growth to occur on the left end of the material. In future work, the model may be extended to simulate the interplay of growth due to both mechanical and chemical stimulation.