Magnetic resonance techniques to study damage evolution in muscle

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Introduction

Pressure sores are localised areas of tissue breakdown in soft tissues. They are primarily caused by prolonged mechanical loading. It is not known how these external mechanical loads result in tissue damage.

A new rat model was developed by Bosboom [1] in which the tibialis anterior muscle was compressed between an indentor and the tibia. It was demonstrated that T2-weighted MRI is a promising alternative for histological examination to evaluate muscle tissue. However, the model contained too many inaccurracies to study the influence of duration and magnitude of pressure and the influence of (re)perfusion on the development of muscle damage.

Objective

To study damage thresholds, perfusion and deformation of soft tissue during and after mechanical loading using Magnetic Resonance techniques

Methods

To be able to simultaneously collect MR data and apply pressure to the muscle, a MR-compatible loading apparatus is being developed, in which an anaesthetized rat can be placed.

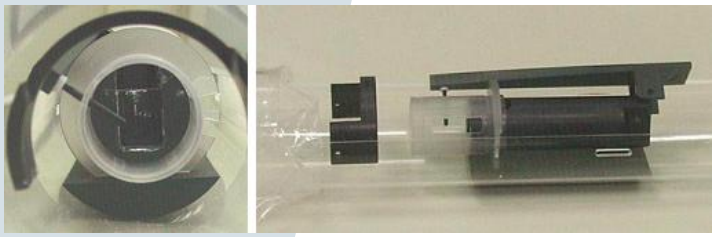

Figure 1 *Loading device, front and side view*

The hind leg of the rat is placed in a radio-frequency coil. A water-filled indentor (which makes it visibile on the MR images, see figure 2) can be moved through the legs of the coil.

Figure 2 *Indentor visible on MR image*

The force will be applied by a linear actuator and can be applied in less than 100 ms, which allows for tracking muscle deformation using MRI tagging methods. The deformation will be compared to finite element modelling of tissue deformation.

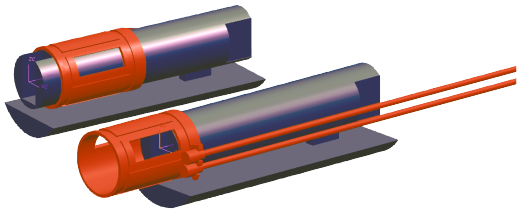

Figure 3 *Different positions of RF coil which makes fixation of the hind limb easier*

MRI measurements will be complemented with 1H- and 31P-MRS studies of the metabolic status of the tissue. 1H-MRS will yield data on lactate formation (as an index of anaerobic glycolysis), while 31P-MRS will provide information on tissue energy charge and intracellular pH, both of which are expected to decline during prolonged loading.

Discussion

The local loading conditions will be carefully controlled and measured for each individual animal. Finite element modeling will be used to determine the mechanical conditions within the muscles during loading. Critical material input parameters for the finite element modeling will be deduced from the MRI data.

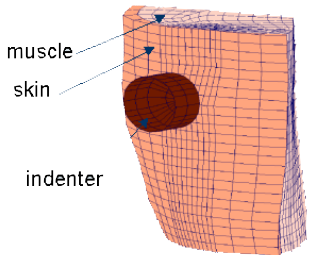

Figure 4 *Three dimensional finite element mesh of muscle, skin and indentor*

Conclusions

With this new set-up we will be able to learn more about the role of deformation, perfusion and damage mechanics in the aetiology of pressure sores.

References:

[1] Bosboom, 2001: *Deformation as a trigger for pressure sore related muscle damage*

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