The biomechanical changes in soft tissues due to musculo-skeletal disorders, as a route for clinical monitoring

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Muscloskeletal Disorders (MSDs) are pathologies concerning the muscles, the joints, and the nerves.

**Primary cause of disability across the world**
1.71 BILLION people globally

In the UK, the NHS each year spends £4.76 BILLION

What is the clinical problem we are addressing?

Every day, doctors use mechanical methods to check the health of their patients by poking the human body.

**OUR FOCUS**
Compartment syndrome (CS), a serious condition that occurs when the pressure within a muscle compartment of the leg increases. It happens following limb trauma, injuries, burns, and prolonged external compression.

Early diagnosis of CS is vital to avoid muscle necrosis. Unfortunately, CS symptoms are subtle in the early stages.

Our objective:
Develop a new quantitative way of evaluating Compartment Syndrome by mechanical assessment of soft tissue changes.

How are we addressing this?

(1) Model of Compartment Syndrome
First, we have developed an animal model of CS on a pig’s leg to replicate the physiological changes during the condition. This was obtained by injecting blood from the bone through and around the muscle.

(2) Mecahnical assessment tool
To enable mechanical assessment of CS we developed a hand-held indentation device by combining three main components: a load cell, which measured the indentation force, a motor and an accelerometer.

The device is hand-held on the surface of the leg. Once the tip touches the surface, indentation is applied. The peak force was calculated at different pressure cases: 0 mmHg and 40 mmHg.

(3) Non-invasive anatomy assessment
In order to observe the differences in the mechanical properties at the surface of the pig’s leg, Digital Image Correlation was also applied. Two cameras were used at different angles: one from the top and one from the side of the pig’s leg. Videos of the legs were taken when different pressures were applied internally.

What have we found?

(A) Indentation tests: Force-displacement curve, comparing different pressures. When a pressure is applied internally, the measured peak force gets higher.

(B) Comparison of Young’s modulus, elastic property of a material, using different speeds. Significant differences between the two pressure cases were found.

(C) Digital Image Correlation (DIC) while applying various pressures inside the leg and the deformation on the skin surface was measured. The bigger the pressure, the more visible the increase in strain is (red colour).

What does this mean?

- Our model of compartment syndrome replicates the human pathology of the condition. The local muscle pressures reaches values higher than 40 mmHg, which correlate with observed human physiology in CS [1].

- Our mechanical assessment tool provides information on how the skin’s surface and the elastic properties (i.e. Young’s Modulus) vary accordingly at different pressure values.

- The Digital Image Correlation technique allows us to visualise and track non-invasively the changes on the skin surface in the different stages leading to compartment syndrome.

The impact

- Compartment syndrome is recognised as needing improved clinical management tools [2]. A less invasive and more accurate diagnostic method needs to be developed.

- Our approach provides both a model that reflects physiological behaviour of CS, and two methods (indentation and DIC) for in-situ non-invasive assessment and monitoring.

- Our results have demonstrated the feasibility of minimally invasive ways to assess compartment syndrome, which have potential for translation to a clinical setting.

References