Aetiology of deep tissue injury: a shift in paradigm

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Introduction
Deep tissue injury (DTI) is a severe kind of pressure ulcer that starts in deep tissue layers, such as skeletal muscle, as a result of mechanical loading. Traditionally, ischaemia is considered to be the only cause of DTI.

Role of deformation
Deformation was hypothesised as a direct cause of damage. Animal experiments were performed in which T$_2$-weighted MRI was used to determine muscle damage after 2 h mechanical loading. An increase in T$_2$ is a measure of swelling and damage. Dedicated finite element models were used to investigate local tissue deformations (fig. 1).

![Fig. 1: Areas with elevated T$_2$ values (measure of muscle damage, white area) were compared with internal deformations.](image)

Damage occurred only in high-strain areas, and deformation correlated with the amount of muscle damage. Moreover, a threshold for damage was found that only depends on deformation. The exposure time influenced the amount of damage, and temporary load reliefs (as used in clinical practice) did not affect the development of muscle damage (fig. 2) [1]. Thus, within a 2 h loading period, deformation is the primary trigger for muscle damage.

![Fig. 2: There exists a mechanical threshold for muscle damage. a) Above this threshold, 2 h causes more damage than 10 min loading. b) Temporary load reliefs during a 2 h loading period did not affect the results.](image)

Role of ischaemia and reperfusion
The effects of ischaemia and reperfusion were investigated using a tourniquet. MRI was used to study perfusion (dynamic contrast-enhanced MRI) and muscle damage (T$_2$-weighted MRI). Severe tissue swelling (increase in T$_2$) was observed after 6 h ischaemia (fig. 3).

![Fig. 3: Perfusion (contrast enhancement) and swelling (T$_2$) during 6 h ischaemia.](image)

Reperfusion after 4 h ischaemia caused a decrease in swelling in some areas. In other regions, reperfusion was absent, associated with a further increase in T$_2$ (fig. 4).

![Fig. 4: Perfusion (contrast enhancement) and swelling (T$_2$) during 4 h ischaemia followed by 2 h reperfusion.](image)

New hypothesis
Deformation is the primary trigger for muscle damage within the first 2 h of loading. Ischaemia becomes involved in the damage process after 2-4 h of loading (fig. 5).

![Fig. 5: Schematic overview of a new hypothesis for the onset of DTI.](image)

References