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The Biomechanical Influence of Static Friction and Shearing on Heel Tissue Damage

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Introduction

The technology of friction production is important to understand in the context of etiology.

Friction between the body and the support surface affects all levels of tissues, from the more superficial levels (skin) to the deepest tissues (surrounding the bones).

As we apply our bodyweight (sitting, lying in bed) we distort and deform the tissues, through the complex forces of compression, stress and shear.

When tissues are stressed, the mechanical loads are transferred from macro level (tissues) to micro level (cells). Cells and cell structures are distorted.

While individual cells are mechanically designed to support loads, if you exceed the maximum load, you can damage the internal and external cell structures.

The Role of Deformation in Cell Death and Wound Generation

Even without the effect of compromised perfusion (which leads to reduced oxygen, changes in metabolism, accumulation of waste products, decreased cell pH and eventual cell death), sustained tissue deformations on their own can damage cell structure and function.

Any structure, living or otherwise, will be damaged by prolonged deformation.

If you deform a living body without the ability to respond to that load (muscular impairment, anesthesia) and the deformation is sustained, it will break down the cytoskeleton of the cell and the cell membrane will fail. The cell will lose the ability to control transport and other homeostatic factors and the result will be cell death by necrosis.

While impaired perfusion affects cell viability in 6-8 hours, deformation damage can happen in just a few minutes (especially on support surfaces such as spinal boards).

Deformation is a primary cell killer.

To measure deformation, we use imaging to actually demonstrate, visualize and quantify distortion, especially in weight-bearing MRI trials. You can then recreate those loads and look at tissue viability at the microscopic level. The result: a model of tissue to which you can apply controlled loads in controlled conditions (thermodynamic, etc.) and look at the tissue at the scale of individual cells.

The Role of Friction in Deformation

Think about a patient in bed. His body weight pulls his body downwards (especially if the head is elevated). Any time he moves or is moved, there is friction – lots of friction – between the skin and whatever the skin touches (clothing, mattress, support surface.) It creates shear stress in the tissue which translates to shear deforming the structure of all the tissue's individual cells.

Basic physics indicates that frictional forces at contacting surfaces are proportional to the coefficient of friction. If two rough materials move past each other, they will create high friction (like when a car tire contacts the road). If both surfaces are smooth, the coefficient of friction is very low (like when ice contacts ice).

If the surrounding atmosphere is hotter or moister than usual, surfaces will change their physical properties, which will affect their friction coefficient when interacting with other surfaces.

Skin, for example, will become more wrinkled (a change in topography) creating more friction. Repositioning a patient whose skin is wet, especially if dragging the patient in bed, may result in superficial and deep tissue damage.

Frictional forces generated at the contact of the heels with the support are transferred to internal tissues which distorts cells in these tissues, leading to tissue injury and heel ulcers.

In order to minimize deformation from shear, you need to minimize friction.

How?

Ways to Minimize Friction

1. Offloading
   No contact with any surface means no friction. That's ideal, but often not possible.
2. Low friction materials

Topography, organization and texture of the interface fabric determine the coefficient of friction and hence, the frictional forces applied to tissues.

A regular polycotton sheet has rough topography (relatively speaking). But Parafricta fabric has controlled topography properties designed to minimize friction. By putting two of these layers together, so they slide against each other, it MINIMIZES friction, preventing it from affecting the body.

Conclusions:

- Sustained bodyweight deformations cause cell and tissue damage
- Deformation damage occurs rapidly so prevention must be timely
- Frictional forces cause tissue shearing at the skin and in deep tissues
- The posterior heels are vulnerable to friction-related shear damage
- Low-friction fabric garments are effective in reducing the frictional forces
- Prevention by (among other measures) managing friction is the way forward