Finite Element Modeling and Analysis of Shear Stresses on the Buttocks while lying on a Spine Board
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Introduction

- Spine board is used to immobilize patients with spinal injury.
- Immobilization of spine is of utmost importance.
- Removal of patients from spine board becomes a low priority for the hospital staff.
- Prolonged stay results in pressure ulcers (PU).
- A PU is a localized injury to the skin and underlying tissue, usually over a bony prominence, as a result of pressure or pressure in combination with shear [1].
- Hence it is necessary to understand and minimize the tissue loading experienced by a patient while immobilized on a spine board.
- Previous studies focused on assessing the normal pressure acting on the skin and the Von-Mises stresses acting in the tissues.

Objective

The objective of this study is to estimate the shear stresses experienced on the buttocks when a patient is immobilized on a spine board with cushions of various stiffness.

Computer Aided design data

- Zygote solid 3D male human body CAD model
- The model includes bones, muscles, fat and skin

Finite Element Modeling

- HyperMesh software was used.
- Tetra mesh was used to mesh the bones, the muscles, the fat and the skin
- The mesh size used was 3mm – 6mm.
- The cushion was meshed with hexa mesh of size 6mm.

Material Properties

- Bones: linear elastic isotropic (E= 7GPa, v=0.3)
- Cushion: linear elastic isotropic (E= 10 KPa to 100 KPa, v=0.3)
- Skin, fat and muscles: Neo-hookean material [2]
- Neo-hookean material is a hyper elastic material

Results

<table>
<thead>
<tr>
<th>Shear modulus (μ) MPa</th>
<th>Bulk modulus (K0) MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>0.2138</td>
</tr>
<tr>
<td>Fat</td>
<td>0.000286</td>
</tr>
<tr>
<td>Muscle</td>
<td>0.0071</td>
</tr>
</tbody>
</table>

Discussion and Conclusions

- Frictional shear stresses at the buttocks cannot be ignored when immobilized on a spine board.
- Significant changes occur in the shear stresses induced in the tissues when the cushion properties are changed.
- A relationship is proposed to estimate the maximum shear stresses at the buttocks in terms of the maximum normal pressure for different Young's modulus of cushion
- These results can be used as a guide to select the cushion material that minimize normal and shear interface stresses and thus prevent the formation of pressure ulcers

References