THE IMPACT OF OCULAR PRESSURES, MATERIAL PROPERTIES AND GEOMETRY ON OPTIC NERVE HEAD DEFORMATION

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Background and Purpose

• Elevated intracranial pressure (ICP) is involved/implicated in several ocular conditions: papilledema, glaucoma and Visual Impairment and Intra-cranial Pressure (VIIP) syndrome
• ICP affects optic nerve head (ONH) biomechanics
• There are likely important inter-individual differences in biomechanical response to ICP, e.g. due to differences in ONH tissue properties.
• Goal: To develop a finite element (FE) model to simulate how inter-individual differences in pressures, tissue material properties and ocular geometry affect the deformation of ONH tissues.

Methods: Finite Element Model

• Extend Sigal et al.’s (IOVS, 2005) geometric model of the posterior eye and ONH

• Tissue material properties: taken from literature and/or estimates.

Methods: Latin Hypercube Sampling

• Simulate a virtual population: to account for inter-individual variations in pressures and tissue mechanical properties
• Intraocular pressure (IOP) and mean arterial pressure (MAP) values measured in-flight.
• Three different ICP conditions considered: upright on earth (upright), supine on earth (supine) and microgravity (elevated).
• Assess how changes in several ocular geometric parameters influenced strain distributions under elevated ICP conditions (Table)

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<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Low</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>Scleral Radius (mm)</td>
<td>12</td>
<td>9.6</td>
<td>14.4</td>
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<tr>
<td>Scleral Thickness (mm)</td>
<td>0.8</td>
<td>0.64</td>
<td>0.96</td>
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<tr>
<td>Pia Thickness (mm)</td>
<td>0.06</td>
<td>0.048</td>
<td>0.072</td>
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• Primary outcome measures: Peak tensile and compressive strains in the LC and post-laminar optic nerve (shaded region)

Summary and Conclusions

• 47% of individuals experience “extreme strains” in the optic nerve with elevated ICP
  • c.f. 41% of astronauts suffering from VIIP syndrome
  • Scleral and pia thickness influenced the peak strains in the lamina cribrosa and post-laminar neural tissue, respectively.
• Future computational work should examine how additional or multiple geometric variations influence extreme strains under elevated ICP conditions

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