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Characterising 3D Soft Tissue Features on Joint Surfaces

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Prevalence of Knee Arthritis - Subgroups

(Ref: Woolf & Pfleger, 2003)
Prevalence of Knee Arthritis - Subgroups

Gender breakdown, >500 patients with isolated patellofemoral arthritis

Male 28%
Female 72%

(Ref: Dejour 2004)
Knee Anatomy and Kinematics

• Hypothesis: That soft tissue geometry is a key driver of both kinematics and disease development in the knee joint

• Objectives
  • Investigate Shape – Gender, Ethnicity Effects
  • Investigate links between Anatomy & Kinematics

➤ Modeling soft tissue anatomy crucial.

• Issues:
  • Multi-modality
  • Absence of landmarks
  • Complex surfaces
Tools

- Mesh smoothing, cutting, simplifying, etc.
- 3D shape/size analysis tools
- Extendable Plug-ins
- Command line interface
Patellar Cartilage Thickness Study

**Input Data**
- 32 CT / MRI patella scans

**Pre-processing**
- smoothing, simplification

**Surface Registration**
- consistent parameterisation, registration of soft tissue data

**Cartilage Distribution Analysis**
- group difference in cartilage maps – Gender / Ethnicity Comparison
## Patellar Cartilage Thickness Study

<table>
<thead>
<tr>
<th>Data Groupings</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Asian</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>
Methodology: Registration of Soft Tissue Data to Bone Models
Gender Difference Results: Raw Data

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Cartilage Thickness (mm)</td>
<td>1.3</td>
<td>1.06</td>
<td>23</td>
</tr>
<tr>
<td>S.D. of Cartilage Thickness (mm)</td>
<td>1.74</td>
<td>1.45</td>
<td></td>
</tr>
</tbody>
</table>
Gender Difference Results: Size-Corrected Data

<table>
<thead>
<tr>
<th>Male and Female Mean Model Data</th>
<th>M</th>
<th>F</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Cartilage Thickness (mm)</td>
<td>1.22</td>
<td>1.12</td>
<td>8.9</td>
</tr>
<tr>
<td>S.D of Cartilage Thickness (mm)</td>
<td>1.64</td>
<td>1.53</td>
<td></td>
</tr>
</tbody>
</table>

Cartilage Thickness Values (mm)

Male Mean Shape and Distribution

Female Mean Shape and Distribution

Overall Mean Shape, Male - Female Distribution Comparison
Ethnicity Difference Results: Size-Corrected Data

<table>
<thead>
<tr>
<th>White and Asian Mean Model Data</th>
<th>W</th>
<th>A</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Cartilage Thickness (mm)</td>
<td>1.25</td>
<td>1.07</td>
<td>17</td>
</tr>
<tr>
<td>Variance in Cartilage Thickness (mm)</td>
<td>1.3</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions and Future Work

• Ethnic cartilage thickness variations more significant than gender variations (17% vs. 9%)

• Developed tool with potential to predict soft tissue shape from bony geometry, and correlate with contact patterns to link with kinematic models
Conclusions and Future Work

(McWalter, UBC, 2009)
Conclusions and Future Work

• Ethnic cartilage thickness variations more significant than gender variations

• Developed tool with potential to predict soft tissue shape from bony geometry, and correlate with contact patterns to link with kinematic models

• Need to:
  • Increase sample size
  • Apply registration technique to femur, tibia, ligament attachments
  • Examine standard deviations of thickness values at each node
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