Contribution of the Pubofemoral Ligament to Hip Stability: A Biomechanical Study

E-Poster Abstract # 1808

Anthony Khoury M.Sc.\textsuperscript{1,2}; Ricardo G. Schröder, PT\textsuperscript{2}; Eric Johnson B.S.\textsuperscript{2,3}; Salvador Campos, M.D.\textsuperscript{2}; Ian J. Palmer, PhD\textsuperscript{2}; Hal D Martin, DO\textsuperscript{2}

1. Department of Bioengineering, UT Arlington, Arlington, Texas, U.S.A.
2. Hip Preservation Center, Baylor Scott & White Research Institute, Dallas, Texas, U.S.A.
3. College of Medicine, Oklahoma University, Oklahoma City, OK, U.S.A.
Disclosure

HDM— Educational Consultant for Smith & Nephew

ANK, RGS, EJ, SC, IJP — N/A
Background

• The capsule enclosing the hip joint significantly contributes to stability during dynamic and static motions, with additional assistance from the Ligamentum Teres

• Four ligaments comprise the hip capsule: medial and lateral arm of Iliofemoral ligament, Ischiofemoral ligament, Pubofemoral ligament

• To date, the proper biomechanical contribution of the Pubofemoral ligament to hip stability is not understood
Background

• Advanced knowledge of the biomechanical relationship of the hip capsular ligaments is required to understand their influence during joint motion and overall stability.

• The purpose of this study was to determine the isolated function of the Pubofemoral ligament of the hip capsule and its contribution to hip stability in external/internal rotational motion during flexion greater than 30 degrees, and abduction.
Methods

• 13 hips from 7 fresh-frozen pelvis-to-toe cadavers were skeletonized from the lumbar spine to the distal femur, preserving the hip capsular ligaments

• Each specimen underwent a standard physical examination of the hip, pelvis, and spine to ensure no occult pathological state existed

• The Ligamentum Teres was assessed arthroscopically to ensure it was intact
Methods

- All specimens underwent CT imaging evaluation of the pelvis and lower limbs to assess boney anatomy
  - The feet were fixed in a neutral position with 0 degrees abduction
  - Anatomic measures included: Femoral Neck Version, Acetabular Version measured at the 3 o’clock position, Femoral Neck Shaft Angle, Knee Varus/Valgus Angle, and CT Leg Length

- Specimens were positioned supine, with the pubic symphysis on the same horizontal plane as both anterior superior iliac spines. The specimens were secured with 4 holding pins.
  - A frame was designed to hold the lower extremity in each measurement position, while allowing unobstructed hip rotation
Methods

- A trained Physical Therapist manually performed all hip maximal internal and external rotations. The hip positions were a combination of abduction (0°, 20° abduction, 40° abduction) and flexion (30°, 60°, and 110° of flexion)
  - Position order was randomized
  - Three measurements of maximal internal and external rotation were recorded at each endpoint
- Following native testing, the Pubofemoral ligament was released at the inferior border, through the zona orbicularis, and adjacent to the labrum to the border of the Iliofemoral ligament
  - Testing sequence was repeated
- The Ligamentum Teres was released using an arthroscopic blade
  - Testing sequence was repeated
- **162 total measurements: 54 in native, 54 with Pubofemoral ligament cut, 54 with Pubofemoral ligament and Ligamentum Teres cut**
## Results

### Cadaveric specimen specifications

<table>
<thead>
<tr>
<th>Cadaver</th>
<th>Age</th>
<th>Sex</th>
<th>MCKIBBIN</th>
<th>FNV</th>
<th>AV</th>
<th>FNSA</th>
<th>KA</th>
<th>CT Leg Length</th>
<th>FNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1R</td>
<td>70.0</td>
<td>M</td>
<td>50.4</td>
<td>28.1</td>
<td>22.3</td>
<td>123.0</td>
<td>17.2</td>
<td>79.01 cm</td>
<td>10.9</td>
</tr>
<tr>
<td>2L</td>
<td>60.0</td>
<td>M</td>
<td>33.8</td>
<td>12.3</td>
<td>21.5</td>
<td>127.4</td>
<td>-2.2</td>
<td>86.3 cm</td>
<td>14.5</td>
</tr>
<tr>
<td>2R</td>
<td>M</td>
<td></td>
<td>38.5</td>
<td>11.9</td>
<td>26.6</td>
<td>128.4</td>
<td>6.9</td>
<td>86.6 cm</td>
<td>5.0</td>
</tr>
<tr>
<td>3L</td>
<td>65.0</td>
<td>M</td>
<td>17.5</td>
<td>-0.4</td>
<td>17.9</td>
<td>131.0</td>
<td>-17.0</td>
<td>85.3</td>
<td>16.6</td>
</tr>
<tr>
<td>3R</td>
<td>M</td>
<td></td>
<td>4.1</td>
<td>-7.2</td>
<td>11.3</td>
<td>128.3</td>
<td>-14.8</td>
<td>84.4</td>
<td>7.6</td>
</tr>
<tr>
<td>4L</td>
<td>37.0</td>
<td>M</td>
<td>24.5</td>
<td>10.4</td>
<td>14.1</td>
<td>139.9</td>
<td>-9.2</td>
<td>79.3</td>
<td>19.6</td>
</tr>
<tr>
<td>4R</td>
<td>M</td>
<td></td>
<td>9.6</td>
<td>0.5</td>
<td>9.1</td>
<td>126.1</td>
<td>-13.8</td>
<td>78.8</td>
<td>14.3</td>
</tr>
<tr>
<td>5L</td>
<td>51.0</td>
<td>M</td>
<td>38.7</td>
<td>32.5</td>
<td>6.2</td>
<td>124.8</td>
<td>0.0</td>
<td>76.8</td>
<td>32.5</td>
</tr>
<tr>
<td>5R</td>
<td>M</td>
<td></td>
<td>46.3</td>
<td>33.2</td>
<td>13.1</td>
<td>129.8</td>
<td>0.0</td>
<td>77.0</td>
<td>33.2</td>
</tr>
<tr>
<td>6L</td>
<td>38.0</td>
<td>F</td>
<td>29.8</td>
<td>9.7</td>
<td>20.1</td>
<td>131.5</td>
<td>-13.6</td>
<td>76.7</td>
<td>23.3</td>
</tr>
<tr>
<td>6R</td>
<td>F</td>
<td></td>
<td>32.5</td>
<td>19.8</td>
<td>12.7</td>
<td>127.9</td>
<td>3.5</td>
<td>77.1</td>
<td>16.3</td>
</tr>
<tr>
<td>7L</td>
<td>72.0</td>
<td>F</td>
<td>12.2</td>
<td>8.2</td>
<td>4.0</td>
<td>123.2</td>
<td>3.1</td>
<td>78.8</td>
<td>5.1</td>
</tr>
<tr>
<td>7R</td>
<td>F</td>
<td></td>
<td>4.2</td>
<td>3.1</td>
<td>1.1</td>
<td>134.4</td>
<td>-6.8</td>
<td>79.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Average</td>
<td>26.3</td>
<td>12.5</td>
<td>13.8</td>
<td>128.9</td>
<td>-3.6</td>
<td>79.4</td>
<td>16.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

• The average of the three measure of internal and external rotation was used for analysis

• Repeated measures ANOVA by ligamentous state (Native vs –Pubofem, vs –Pubofem&Teres) were run for internal and external rotation at each position of flexion and abduction

  – When a main effect of internal or external rotation was found, post-hoc independent t-test analyses were performed
Results

Control of Hip Rotation Comparing Ligamentous State with Increased Abduction at 30°, 60°, and 110° Flexion

* p<0.05 compared to Native state, † p<0.05 compared to pubofemoral ligament released state. Native is all ligaments intact, -pubofem refers to the released pubofemoral ligament, and -pubofem&teres refers to the released pubofemoral ligament and ligamentum teres.

Control of Hip Rotation within Ligamentous State Comparing Increased Flexion at 0°, 20°, and 40° Abduction

* p<0.05 compared to 30° Flexion, † p<0.05 compared to 60° Flexion. Native is all ligaments intact, -pubofem refers to the released pubofemoral ligament, and -pubofem&teres refers to the released pubofemoral ligament and ligamentum teres.
Conclusion

• The Pubofemoral ligament maintains a key function in limiting hip internal rotation in the position of increasing hip flexion beyond 30° and abduction. The cadaveric study concludes previous attempts at understanding the anatomical and biomechanical function of the capsular ligaments and their role in hip stability.
References


