Hamstrings Loading Contributes to Lateral Patellofemoral Malalignment and Elevated Cartilage Pressures

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INTRODUCTION

Patellofemoral pain is commonly attributed to lateral malalignment and subsequent overloading of patellofemoral cartilage. An elevated lateral orientation of the patella tendon can be a primary contributor to lateral malalignment. While an abnormal patella tendon orientation is commonly attributed to knee anatomy, tibiofemoral kinematics also influence the orientation of the patella tendon. In particular, posterior translation and external rotation of the tibia increase the compressive force and lateral force applied to the patella, respectively, both of which can elevate the pressure applied to cartilage. In vitro studies have shown that activation of the hamstrings muscles causes tibial posterior translation and external rotation [1, 2], indicating that activation of the hamstrings could exacerbate lateral malalignment and overloading of cartilage in patients with patellofemoral pain. The current study was performed to evaluate the influence of hamstrings loading on patellofemoral kinematics and the pressure applied to cartilage for a laterally malaligned patellofemoral joint.

METHODS

Ten cadaveric knees were secured to a testing frame at 40°, 60° and 80° of flexion (Fig. 1). Loads were distributed among the quadriceps muscles in a pattern that simulated vastus medialis obliquus weakness with a total quadriceps force of 586 N [3]. Loading cables connected to weights over pulleys were clamped to the muscles at their insertion sites. Lateral malalignment was further simulated by osteotomizing the tibial tuberosity, and securing it on the tibia 5 mm lateral to the original position. The quadriceps were loaded alone and in combination with 200 N split between the medial and lateral hamstrings.

Patellofemoral translations and rotations, and the patellofemoral force and pressure distributions were quantified for each test. A sensor from a magnetic tracking system (trakSTAR, Ascension Technology) was used to digitize landmarks to establish reference axes for the femur and patella. Sensors were also attached to the femur and patella to track the motions of the reference axes during testing. Patellofemoral translations and rotations were quantified using the floating axis coordinate system [4]. Maximum lateral and medial pressures and the lateral force percentage were measured with a calibrated sensor (I-Scan, Tekscan), which was inserted into the joint. The lateral force percentage is the percentage of the total joint compression applied to cartilage on the lateral facet. The position of the patella ridge was identified by palpating the sensor during testing. At each flexion angle, paired t-tests were performed for each output parameter to determine if loading the hamstrings significantly (p < 0.05) influenced the data.

RESULTS

Loading the hamstrings increased patella flexion and the lateral tilt and shift of the patella, and shifted force and pressure from the medial facet to the lateral facet. Loading the hamstrings increased the average patella flexion by less than 2°, with the increase statistically significant at each flexion angle (Table 1), increased the average lateral tilt by 0.5° or less, with the increase significant at 40° and 60°, and increased the lateral shift by less than 0.5 mm, with the increase significant at 60° and 80°. Loading the hamstrings increased the lateral force percentage by approximately 6% (Fig. 2), with the increase significant at each flexion angle, increased the maximum lateral pressure by approximately 0.4 MPa (Fig. 3), with the increase significant at 40° and 60°, and decreased the maximum medial pressure by approximately 0.2 MPa, although the change in the maximum medial pressure was not significant.

Table 1: Average (+ standard deviation) patellofemoral kinematics at 40°, 60° and 80° of knee flexion.

<table>
<thead>
<tr>
<th>Flexion (deg)</th>
<th>Lateral Tilt (deg)</th>
<th>Lateral Shift (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Hams</td>
<td>Hams</td>
</tr>
<tr>
<td>40°</td>
<td>30.1±9.7*</td>
<td>31.1±10.0*</td>
</tr>
<tr>
<td>60°</td>
<td>44.5±9.7*</td>
<td>46.1±9.8*</td>
</tr>
<tr>
<td>80°</td>
<td>59.7±9.9*</td>
<td>61.2±9.9*</td>
</tr>
</tbody>
</table>

* indicates significant difference at a flexion angle; Hams: Hamstrings

DISCUSSION

The data indicates that hamstrings contraction in a laterally malaligned knee exacerbates lateral malalignment and elevates lateral pressures. The redistribution of force and pressure due to tibial external rotation and increased lateral shift and tilt of the patella seems to be more prominent than increased compression due to tibial posterior translation and increased patellar flexion. Activities that minimize hamstrings activation could reduce the risk of overloading lateral cartilage in patients with patellofemoral pain related to lateral malalignment.

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REFERENCES