Proximal Tibial Osteotomy and Meniscal Transplantation: A Biomechanical Analysis

Introduction

Meniscectomy is a common procedure that has been shown to biomechanically increase tibial contact force with a decreased tibial contact area. Thus, meniscal transplantation has recently experienced increased clinical applicability.

It is often recommended to perform a high tibial osteotomy (HTO) in the setting of a varus-aligned knee prior to performing a meniscal transplantation. The HTO is advocated to unload the medial compartment, improve overall joint mechanics, and potentially improve the longevity of the meniscal transplant tissue. However, it is not known if an HTO prior to meniscal transplantation is necessary to improve joint contact forces.

The purpose of this study was to determine the optimal alignment and clarify the biomechanical effects that an HTO has on a meniscal transplantation. We hypothesize that an HTO will further improve the medial compartment contact pressures in the context of a meniscal transplantation. This scenario has not been well studied, and has the potential to translate into improved clinical outcomes.

Methods

1. 6 cadaver knees available for testing
2. Radiographs were taken to determine anatomic alignment
3. Knees were dissected down to capsule and placed in a Taylor Spatial Frame (Smith and Nephew, Memphis, TN) (Figure 1)
4. Valgus osteotomy was completed
5. Tekscan (Boston, MA) sensors were placed sub-meniscal in both the medial and lateral compartments
6. Knees were mounted in an MTS machine in extension (Figure 1)
7. Photo analysis was used to determine approximately 3º of anatomic valgus - defined as mechanical "neutral"
8. Neutral alignment was confirmed by loading the knee so that 60% of the pressure was medial and 40% was lateral
9. The knee was then loaded to 800 N from 6º varus to 8º valgus for a meniscal intact, meniscectomized, and transplanted state
10. Meniscal transplant was done using a bone slot/trough technique with the original meniscus re-implanted
11. Total pressure and peak pressures were recorded and an ANOVA analysis with post-hoc testing was used to determine significance

Results

The table below illustrates the peak contact pressures in the medial compartment. The intact and transplanted states have significantly lower peak stresses at neutral and all degrees of valgus than the meniscectomized condition (p<0.05). Figures 2, 3 and 4 illustrate the total and peak pressures in the medial compartment and the combined values (medial and lateral).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Intact</th>
<th>Deficient</th>
<th>Transplant</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Varus</td>
<td>27.85±4.09</td>
<td>34.79±4.86</td>
<td>31.13±3.81</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>3 Varus</td>
<td>23.90±5.21</td>
<td>33.23±4.19</td>
<td>27.54±6.56</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Neutral</td>
<td>19.49±2.51</td>
<td>27.62±2.11</td>
<td>21.58±4.90</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>3 Valgus</td>
<td>9.59±5.27</td>
<td>19.26±4.76</td>
<td>12.92±5.15</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>6 Valgus</td>
<td>8.62±7.08</td>
<td>13.34±4.59</td>
<td>9.18±8.99</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>8 Valgus</td>
<td>4.88±7.92</td>
<td>10.07±11.39</td>
<td>3.14±5.19</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Neutral – Slope</td>
<td>16.63±2.66</td>
<td>25.93±5.42</td>
<td>18.31±4.54</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>3 Valgus – Slope</td>
<td>13.71±5.04</td>
<td>21.60±5.86</td>
<td>12.19±5.44</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>6 Valgus – Slope</td>
<td>7.93±9.93</td>
<td>13.39±11.36</td>
<td>7.35±7.78</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

Discussion

This study confirms the concept that a valgus producing high tibial osteotomy improves the medial compartment environment in the context of a meniscal transplant. Peak and total contact pressures were significantly decreased with an HTO at almost all angulations. Furthermore, figures 2 and 3 illustrate a significant decrease in medial pressures from neutral to 3º of mechanical valgus. This fact, is also suggested in the combined peak pressure values for the intact and transplanted state (figure 4). There was no significant change in contact pressures with a 3º increase in posterior slope that is often experienced with an HTO.

These biomechanical results suggest a couple conclusions:
- An HTO will improve the medial pressure profile in addition to a meniscal transplant.
- Valgus re-alignment improves knee stresses for a varus knee.
- The increased slope associated with a high tibial osteotomy does not affect the pressures of the medial compartment.
- The medial compartment of a neutrally aligned knee significantly benefits from correction to 3º mechanical valgus (red box – Figures 2 and 3).
- Combined peak pressures in meniscal intact knees appear to reach an “ideal” value at 3º of mechanical valgus.