Utility of dynamic stress ultrasound in quantifying medial knee ligament injury

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DISCLOSURE

- There are no potential conflicts of interest related to this study

- Other Relevant Disclosures:

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• Medial knee ligament injuries can lead to valgus instability of the knee, and the severity of instability can dictate the need for surgical treatment.

• Stress radiography can provide an objective measure of medial knee injury but cannot be performed outside of the radiography suite.

• Stress ultrasonography has been shown to have value in quantifying dynamic movement in the knee but has not yet been applied for this purpose.
To quantify the severity of medial knee injuries based on medial compartment gapping as measured by stress ultrasound.
• In 8 unpaired cadaveric knees, the distance between the medial tibial and femoral condyles was measured using ultrasound.

• These measurements were obtained in the intact state and repeated after open sequential transection of the superficial medial collateral ligament (sMCL), deep MCL (dMCL), posterior oblique ligament (POL), and arthroscopic transection of the anterior cruciate ligament (ACL).

• Knees were evaluated at 0° and 20° of knee flexion using the Telos device under 0N and 100N of valgus force.
• Ultrasound images were obtained in each injury state.
• Measurements on ultrasound images were performed using Image J.
• One-way ANOVA with post-hoc Tukey HSD - To test for significant differences in medial tibiofemoral distance between each stage of ligament transection, and at each sequential stress measurement.
• Area under the receiver operating characteristic (ROC) curve analysis and Delong test - To determine whether measurements could distinguish between successive severity of MCL injury.
• Youden’s J statistic - To determine the optimal cutoff value to distinguish between each injury state.
### RESULTS

**Table 1.** Measurements of the medial tibiofemoral distance based on ultrasonographic evaluation are shown comparing the intact state with subsequent transection.

<table>
<thead>
<tr>
<th>Stage</th>
<th>0 degree knee flexion</th>
<th>20 degree knee flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unloaded</td>
<td>Loaded (100N)</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD (mm)</td>
<td>Difference compared to Intact state (mm)</td>
</tr>
<tr>
<td>Intact</td>
<td>6.5±1.1</td>
<td>-</td>
</tr>
<tr>
<td>Superficial MCL</td>
<td>7.3±1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Deep MCL</td>
<td>10.7±2.2 b</td>
<td>4.2</td>
</tr>
<tr>
<td>POL</td>
<td>11.9±2.3</td>
<td>5.4</td>
</tr>
<tr>
<td>ACL</td>
<td>14.1±2.5</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Abbreviations: POL, posterior oblique ligament; ACL, anterior cruciate ligament; %; percentage mm, millimeters; SD, standard deviation; CI, confidence interval.

*bStatistically significant change compared with the previous transected stage*
• When measured using ultrasound at 20° knee flexion with valgus load, the medial tibiofemoral distance significantly increased with increasing severity of medial knee injury (p values ranging from 0.049 - < 0.001).

• The optimal cutoff values for distinguishing between an intact knee and sMCL injury was 8.3mm (AUC = 0.98), between sMCL and dMCL injury 9.9mm (AUC = 0.89), dMCL and POL 16.7mm (AUC = 0.88), and POL and ACL 18.6mm (AUC = 0.84).

• When comparing combined intact and sMCL transected stages to dMCL transected stage, the optimal cutoff point to differentiate stable from unstable injuries was equal to 13.8 mm of medial tibiofemoral distance (AUC = 0.97; sensitivity = 100%; specificity = 94.1%)
CONCLUSION

• Dynamic ultrasonographic assessment can accurately quantify the severity of medial knee ligament injury based on medial compartment gapping. In our study, we found medial tibiofemoral distance >13.8 mm at 20° knee flexion under valgus force indicates presence of deep MCL injury with a diagnostic accuracy of 0.97.

• As dynamic ultrasound can be performed without radiation and at point of care in multiple clinical settings, further studies are recommended to study the utility of ultrasound-based assessments in the evaluation and management of MCL injuries.