Assessing Patellar Instability: Relating Tibial Tubercle Trochlear Groove Distance To Patient Specific Anatomy

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Background

- Patients with patellar instability and tibial tubercle to trochlear groove (TT-TG) distances ≥ 20 mm may be candidates for distal tubercle realignment surgery.
- TT-TG has proven valuable in predicting risk of recurrent dislocations.
- However, the strict cut-off TT-TG value (≥ 20 mm) is not individualized to patient size, bony morphology, or patellofemoral mechanics.
- Many other orthopedic measurements and classifications have managed to overcome this shortfall by using either ratios or percentages that are based on patient specific anatomic measures.
- To date, a few attempts have been made to relate TT-TG to patient specific anatomy.
- None of these new measures have been able to predict the risk of recurrent instability.

Post-operative radiographs of a patient undergoing TTO for increased TT-TG.
Purpose of this Study

1) To identify a radiographic measure that relates TT-TG to various anatomical parameters (both novel and previously reported)

2) Establish a more accurate predictor of recurrent patellar instability that respects patient specific anatomy
Methods

• 59 knees with a diagnosis of patellar instability and an MRI available for review were included.

• For all patients, the following measures were obtained by two orthopedists in a blinded and randomized fashion:
  - Tibial tubercle to trochlear groove distance (TT-TG)
  - Tibial tubercle to posterior cruciate ligament distance (TT-PCL)
  - Sagittal patellar length (PL)
  - Sagittal trochlear length (TL)
  - Axial patellar width (PW)
  - Axial trochlear width (TW)

• Using these measures, the following 8 ratios were created:

  TT-TG
  PL  TT-TG
  TL  TT-TG
  PW  TT-TG
  TW  TT-PCL
  PL  TT-PCL
  TL  TT-PCL
  PW  TT-PCL
  TW
Methods

- Patients were divided into two groups:
  - 1) Those experiencing only a single dislocation (n=12, 20%)
  - 2) Those with 2 or more dislocations (n=47, 80%)

- Using these groups, the ability of the ratios to predict recurrent instability was assessed by calculating the following for each measure:
  - Odds ratio (OR)
  - Sensitivity
  - Specificity
  - Positive predictive value (PPV)
  - Negative predictive value (NPV)

- The cut-off values that maximized the predictability of each of the ratios were identified
**Description of Measures**

- **TT-TG**: The deepest portion of the TG was marked on the image in which the trochlear groove (TG) was deepest. The distal most image in which the patellar tendon remained in contact with the TT was then located. The medial to lateral distance between the TG and the center of the TT was taken as the TT-TG.

- **TT-PCL**: The lateral to medial distance between the center of the patellar tendon on the tibial tubercle to the medial border of the posterior cruciate ligament (PCL) on the tibia. This distance was taken tangentially to the dorsal tibia condylar line.

*Images reproduced from Seitlinger et al. AJSM. 2012;40(5):1119-1125*
**Description of Measures**

- **PL**: the greatest proximal to distal length of patellar articular cartilage

- **TL**: Measured on the sagittal MRI image in which the trochlear cartilage extends most proximal. The distance between this superior articular border and the inferior most extent of the PL line is measured as the TL

- **PW**: The PW is the greatest width of the articular surface of the patella.

- **TW**: The TW is the distance from the medial articular border of the patella to the lateral most border of the trochlear cartilage. Each of these distances is tangential to the posterior condylar reference line
Results

- Mean age = 22 (range 12-51)
- Mean follow up = 6.6 years
- Gender: Male 44%, Female 56%

<table>
<thead>
<tr>
<th>Measures</th>
<th>Observer 1 Mean (range)</th>
<th>Observer 2 Mean (range)</th>
<th>Combined Mean (range)</th>
<th>ICC* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT-TG</td>
<td>15.2 (0.1 - 29.1)</td>
<td>15.5 (0.7 – 30.2)</td>
<td>15.4 (0.7 – 29.7)</td>
<td>0.978 (0.962, 0.987)</td>
</tr>
<tr>
<td>TT-PCL</td>
<td>21.7 (8.6 - 30.0)</td>
<td>21.6 (9.5 – 29.5)</td>
<td>21.7 (9.1 – 29.6)</td>
<td>0.932 (0.889, 0.959)</td>
</tr>
<tr>
<td>PL</td>
<td>31.9 (25.4 - 41.3)</td>
<td>32.0 (24.8 - 41.2)</td>
<td>32.0 (25.2 – 41.0)</td>
<td>0.975 (0.958, 0.985)</td>
</tr>
<tr>
<td>TL</td>
<td>17.8 (7.6 – 30.8)</td>
<td>18.0 (7.5 – 31.5)</td>
<td>17.9 (8.0 – 31.2)</td>
<td>0.972 (0.954, 0.984)</td>
</tr>
<tr>
<td>PW</td>
<td>38.3 (29.1 – 46)</td>
<td>38.5 (28.6 – 45.9)</td>
<td>38.4 (28.9 – 45.3)</td>
<td>0.966 (0.943, 0.980)</td>
</tr>
<tr>
<td>TW</td>
<td>34.2 (11.5 – 46)</td>
<td>34.4 (10.7 – 46.2)</td>
<td>34.3 (11.1 – 46.1)</td>
<td>0.986 (0.976, 0.991)</td>
</tr>
</tbody>
</table>

*ICC > 0.75 was considered to represent excellent agreement
# Results

## Comparison of Predictive Ability of Ratios

<table>
<thead>
<tr>
<th>Variable</th>
<th>Threshold</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
<th>c-statistic</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT-TG</td>
<td>≥ 20 mm</td>
<td>5.38 (0.59, 713.83)</td>
<td>0.29</td>
<td>0.59</td>
<td>21.3</td>
<td>100.0</td>
</tr>
<tr>
<td>TT-PCL</td>
<td>≥ 24 mm</td>
<td>1.46 (0.31, 6.92)</td>
<td>0.63</td>
<td>0.54</td>
<td>30.0</td>
<td>58.3</td>
</tr>
<tr>
<td>TT-TG/PL</td>
<td>≥ 0.5</td>
<td>3.13 (0.75, 13.04)</td>
<td>0.12</td>
<td>0.63</td>
<td>51.1</td>
<td>75.0</td>
</tr>
<tr>
<td>TT-TG/TL</td>
<td>≥ 0.8</td>
<td>3.22 (0.83, 12.53)</td>
<td>0.09</td>
<td>0.64</td>
<td>61.7</td>
<td>66.7</td>
</tr>
<tr>
<td><strong>TT-TG/PW</strong></td>
<td>≥ 0.4</td>
<td><strong>7.37 (1.47, 36.96)</strong></td>
<td><strong>0.02</strong>*</td>
<td><strong>0.72</strong></td>
<td><strong>61.7</strong></td>
<td><strong>83.3</strong></td>
</tr>
<tr>
<td><strong>TT-TG/TW</strong></td>
<td>≥ 0.5</td>
<td><strong>8.88 (1.14, 69.01)</strong></td>
<td><strong>0.04</strong>*</td>
<td><strong>0.68</strong></td>
<td><strong>44.7</strong></td>
<td><strong>91.7</strong></td>
</tr>
<tr>
<td>TT-PCL/PL</td>
<td>≥ 0.6</td>
<td>0.81 (0.18, 3.73)</td>
<td>0.79</td>
<td>0.52</td>
<td>21.3</td>
<td>75.0</td>
</tr>
<tr>
<td>TT-PCL/TL</td>
<td>≥ 1.5</td>
<td>1.27 (0.29, 5.66)</td>
<td>0.75</td>
<td>0.52</td>
<td>29.8</td>
<td>75.0</td>
</tr>
<tr>
<td>TT-PCL/PW</td>
<td>≤ 0.4 or ≥ 0.75</td>
<td>5.22 (0.99, 27.43)</td>
<td>0.05</td>
<td>0.67</td>
<td>51.1</td>
<td>83.3</td>
</tr>
<tr>
<td>TT-PCL/TW</td>
<td>≤ 0.4 or ≥ 0.75</td>
<td>5.68 (0.67, 48.44)</td>
<td>0.11</td>
<td>0.63</td>
<td>34.0</td>
<td>90.0</td>
</tr>
</tbody>
</table>
Data Summary

- TT-TG $\geq 20$ mm was predictive of recurrent instability with \textbf{OR 5.38} ($p=0.29$)

- The highest OR’s for recurrent instability were noted for:
  - TT-TG/PW $\geq 0.40$ (\textbf{OR 7.37}, $p=0.02$)
  - TT-TG/TW $\geq 0.5$ (\textbf{OR 8.88}, $p=0.04$).

- \textbf{TT-TG/PW $\geq 0.40$}
  - Sensitivity: 62%
  - Specificity: 83%
  - PPV: 94%

- \textbf{TT-TG/TW $\geq 0.50$}
  - Sensitivity: 45%
  - Specificity: 92%
  - PPV: 95%
Conclusions

• Two novel patellar instability ratios have been identified and found to be more predictive of recurrent instability compared to TT-TG alone:
  • TT-TG/PW ≥ 0.40
  • TT-TG/TW ≥ 0.50

• Each of these ratios takes into account patient specific anatomy and can be measured in an accurate and reliable fashion by clinicians.

• These ratios are a step towards overcoming some of the limitations of using TT-TG distance in isolation.
References


