Correlation Between Posterior Tibial Slope and In-vivo Knee Kinematics

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Financial disclosure

- **Araki, D.**
  I have no financial conflicts to disclose.

- **Thorhauer, E.**
  I have no financial conflicts to disclose.

- **Tashman, S.**

- **Fu, FH.**
  Research and Educational Support: Smith & Nephew
  Other Support: Department of Orthopaedic Surgery of the University of Pittsburgh receives funding from Arthrocare, Depuy Synthes, Stryker, Johnson & Johnson, DePuy, DonJoy, Breg, Omeros, Biomet, Mitek
Tibial Slope and ACL

- The posterior slope of the tibia has been increasingly studied as a potential risk factor.
  
  (Dejour H, J Bone Joint Surg Br, 1994)
  (Brandon ML, Arthroscopy, 2006)

- In a radiographic in vivo study, a steeper tibial slope resulted in a significantly greater amount of anterior tibial translation (ATT) in both anterior cruciate ligament (ACL)-deficient and ACL-intact knees.

  (Dejour H, J Bone Joint Surg Br, 1994)
The role of tibial slope and arising questions

- **Cadaveric studies**: an artificially increased tibial slope produced an anterior shift of the tibia relative to the femur.
- **MRI-based studies**: a steep slope of the lateral tibial plateau might specifically be responsible for the injury mechanism.
- **Slope-decreasing osteotomies**: The influence of the tibial slope in the treatment of ACL insufficiency remain unclear.

~ Questions ~

- **Single slope measurement**: An insufficient approximation of its three dimensionality.
  (Feucht MJ, Knee Surg Sports Traumatol Arthrosc, 2013)
- **Correlation with in-vivo knee kinematics** has not been demonstrated.
Purpose

➢ To investigate a correlation between the tibial morphology and the in-vivo knee kinematics.

Hypothesis

➢ Steeper posterior tibial slope would be associated with greater anterior translation of the tibia relative to the femur.
Patient profile

- 22 contralateral (uninjured) knees of ACL reconstructed patients.
- Gender: Male 13, Female 9
- Age: 37.0 ± 12.4 y.o.
- From Nov. 2008 - Jul. 2011

Evaluation

- **3D-CT**: Tibial slope angles (Med. Vs Lat. / Male vs Female)
- **DSX**: Anterior tibial translation (Foot strike to peak force)

✓ Compare the differences of tibial slope angles between genders, medial and lateral compartments.
✓ Check the correlation between tibial slope angles and anterior tibial translations.
Measurement method for tibial slope angle

1. The anatomical axis of tibia was measured using 3D-CT scan data of the proximal tibia and a CT slice of the ankle center.
2. The plane normal to this axis vector was drawn using 3D modeling software (Mimics, Materialise, Leuven, Belgium).
3. The tibial slope was calculated in the medial and the lateral compartments by manually drawing a line in the sagittal plane.
4. Anterior-tibial-translation was scaled according to subjects' body size and correlated with the angle of the posterior tibial slope.
Knee kinematics were determined using the DSX system. The DSX images were acquired at a rate of 180 frames/s from shortly before footstrike through mid-stance for 1 step of the test leg. Knee kinematics were assessed with dynamic radio-stereophotogrammetric analysis, a technique for determining three-dimensional kinematic information from stereo-pair radiographic images of musculoskeletal tissue. Anterior tibial translation relative to the femur were calculated by the joint coordinate system originally described by Grood et al. (Tashman S., J Orthop Res, 2004).
~ Results ~

Tibial slopes measurements

**Male**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Medial</th>
<th>Lateral</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
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**Female**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Medial</th>
<th>Lateral</th>
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<tbody>
<tr>
<td>0</td>
<td>5</td>
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**Medial vs Lateral**

- Significant differences were found between medial and lateral side respectively in both male and female knees.

**Male vs Female**

- The slopes in female patients were significantly steeper than those in male patients in the lateral side.
- No significant gender difference were found in the medial side.
Higher correlations were detected in females than in males.
Tibial slope and ACL injury

- Radiological Lachman test showed a 3mm increase for every 10° increase in slope. (Dejour H, J Bone Joint Surg Br, 1994)

- ACL-deficient and ACL-reconstructed patients with higher posterior tibial slope have more functional knees.
  → Posterior slope VS Cincinnati score (Hohmann E, Arthroscopy, 2010)

- ACL patients had deeper medial and lateral tibial plateaus, as well as an increased posterior slope of the lateral tibial plateau. (Bisson LJ, Arthroscopy, 2010)

- A combination of increased posterior-directed tibial plateau slope and shallow medial tibial plateau depth could be a major risk factor in anterior cruciate ligament injury susceptibility regardless of gender. (Hashemi J, Am J Sports Med, 2010)

- 2D measurement of lateral radiographs insufficiently represents its three dimensionality.

- No in-vivo knee kinematics were compared with tibial slope angles in ACL patients. (Wordeman SC, Am J Sports Med, 2012)
Summary of this study

Tibial slope angles (3D-CT)

- Medial < Lateral \((p < 0.05)\)
- Males < Females \((p < 0.05)\)

Tibial slope angle is significantly steeper in lateral compartment than in medial compartment, and females had steeper tibial slope than males.

Correlation between slope and Anterior tibial translation

- Males < Females

In- vivo anterior tibial translation was more strongly correlated with tibial slope in females than in males.
Conclusion

- A steep posterior tibial slope was positively correlated with in-vivo anterior tibial translation.
- Anterior tibial translation was more strongly correlated with tibial slope in females than in males.
- Females also have a significantly steeper posterior tibial slopes than males.

Differences in posterior slope may contribute to the higher risk of ACL injury in females.