Correlation of PET CT Imaging in ACL Surgery with Tunnel Widening

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Disclosures

- This work was supported in part by the OSU College of Medicine Barnes research scholarship.

- David Flanigan, MD is a consultant for and receives research support from Vericel, Zimmer, and Smith and Nephew; is a consultant for ConMed-MTF and DePuy Mitek; and receives research support from MTF, Histogenics, Aesculap, Cartiheal, Anika Therapeutics, and Moximed.

- Christopher Kaeding, MD receives grant support from Vericel, Mayo Foundation, and Cleveland Clinic.

- Robert Magnussen, MD receives grant support from Biomet.
Background

- ACL grafts undergo a normal ligamentization process within the first 12 months of implantation
  - Full maturation may take longer
- Affected by mechanical and biological factors
  - Ex. graft micromotion and biologic rates of revascularization
- Tibial femoral tunnel widening is a common postoperative finding
  - Unknown clinical significance
  - Complicates graft incorporation and revision reconstruction

Novel Imaging Techniques Useful?

- Imaging is a useful technique to evaluate the size and healing of ACL grafts.
- Molecular imaging finding new applications in orthopedics: Ultra Low Dose Positron Emission Tomography (PET) possible
- Visual and quantitative metabolic images can be correlated with CT and MRI
- $^{18}$FDG –PET has been shown to be effective in following the implanted graft through the healing phases of ligamentization.

Purpose: Pilot Study

- To assess if $^{18}$FDG PET tracer activity after ACL surgery is associated with tunnel widening
- To determine if time affects relationships
Methods

- A review of 42 patients who underwent an ACL reconstruction (ACLR) was performed.
- Basic demographic and operative information were gathered and evaluated.
- 1 mm CT reconstructions
- PET/CT analyzed to compare:
  - Size of tunnel
  - Positive PET uptake
  - Time of Surgery
CT Analysis of Tunnel Size

- Images from PET/CT were evaluated for size of tibial femoral tunnels and positive PET tracer uptake and compared to the original tunnel size.

- Tibial tunnel measurements
  - 1 cm from tibial plateau (T1)
  - At widest aspect (T2)
  - 1 cm from distal aperture (T3)

- Femoral tunnel measurement
  - At widest aspect only
The PET tracer uptake was measured in a semiquantitative way using SUVmax based on region of interest analysis.

- Correlated to rainbow scale representing gradient of activity
- PET/CT were analyzed to compare the size of the tibial femoral tunnel, positive PET tracer uptake, imaging findings, and time after surgery.
Statistical Analysis

- Analysis with standard statistical software (STATA)
- A multivariate logistic regression modeling was utilized to determine relationship between radiotracer uptake and time
  - Controlled for age and BMI
- Defined a 2.5mm difference or greater between groups in tunnel widening after surgery as clinically significant at one year and beyond
Results: Demographics & Graft Size

<table>
<thead>
<tr>
<th>Patient Demographics</th>
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<tbody>
<tr>
<td>Mean Age</td>
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<tr>
<td>Gender</td>
</tr>
<tr>
<td>Mean BMI</td>
</tr>
<tr>
<td>Primary ACLR (n)</td>
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<tr>
<td>Revision ACLR (n)</td>
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<tr>
<td>Mean Graft Size</td>
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Graft size at surgery
- Average: 8.4mm
- Primary 8.3mm (7-10)
- Revision 8.9mm (7-10)
Results: Tunnel Widening

- Tibial tunnels widened more than femoral tunnels
  - Femoral 2.23 mm ave. (0.6-5.1)
  - Tibia 3.76 mm ave. (0.8-13.4)

- Tibial Tunnels widened more proximally than distally
  - Most in sagittal plane

- No difference in tunnel widening between primary and revision ACL
Results: Graft FDG Tracer Activity and Time

- Increased time from surgery decreased the odds of high FDG tracer uptake in both tibial and femoral tunnels ($p=0.00016$)

Time Postoperatively Compared to PET Tracer Uptake

0-6 months | 6-12 months | 12-24 months | 24+ months | Healthy

- Graft Average
- Fem Tunnel
- Tib Tunnel
Results: FDG Activity and Tunnel Widening <12 mo

- **ALL** measured areas of the graft had *increased* widening *independent* of tracer uptake
  - During ligamentization, there was no correlation between uptake and tunnel widening

![Tunnel Widening and Uptake <12 Months](chart.png)
Results: FDG Activity and Tunnel Widening > 12 mo

- ALL measured areas of the graft had **increased widening when tracer uptake was high**, but not when tracer uptake was low
  - During maturation, biologic activity should be low
  - Wider tibial femoral tunnels was associated with persistent biologic activity

**Tunnel Widening and Uptake >12 Months**

![Graph showing tunnel widths and uptake over 12 months](image)

- P=0.0085
- P=0.0296
- P=0.0227
Limitations

- Small sample size
- Each patient imaged at only a single time point
- Uptake at different time points are reflective of different patients
- Mechanism for increased uptake after 12 months unknown
Conclusion

- Increased PET tracer uptake occurs early after ACLR surgery and decreases over time.
- Persistent uptake after one year was associated with tibial and femoral tunnel widening.
  - Tibial tunnels enlarged to a greater extent.
- PET may be appropriate imaging marker of biologic activity of the implanted ACL graft.
  - Suggests that increased biologic activity is associated with tunnel widening at later time points.
- Warrants further investigation.
  - Increased PET uptake associated with bacterial biofilm or contamination?
References

Thank You

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