Background

Anatomic studies of the pediatric PCL demonstrate that the tibial attachment spans the epiphysis, physis, and metaphysis\(^1\). To better reproduce the anatomy of the PCL and avoid direct physeal injury during pediatric PCL reconstruction, a double-bundle PCL reconstruction technique that includes both an all-epiphyseal and an all-metaphyseal tibial tunnel has been proposed.

The purpose of this study was to evaluate tibial tunnel placement in a pediatric double-bundle PCL reconstruction technique that avoids direct physeal injury using a 3-D computer model.

Methods

- 10 skeletally immature cadaveric knee specimens (5-11yo) were used to create 3D model reconstructions from CT scans.
- All-metaphyseal and all-epiphyseal tibial tunnels were simulated maintaining adequate spacing (≥2mm) between the tibial physis and tunnels to avoid injury from heat friction.
- The all-metaphyseal tunnel, simulated at sizes of 5mm, 6mm, and 7mm, entered anteriorly, below the tibial tubercle and exited posteriorly in the metaphyseal PCL footprint, distal to the proximal tibial physis.
- 4mm all-epiphyseal proximal tibial tunnels were simulated to enter the epiphysis antero-medially and exit posteriorly at the central epiphyseal region of the PCL footprint, proximal to the physis.
- The distance was measured from the all-metaphyseal tunnels to the physis posteriorly and from the all-epiphyseal tunnels to the physis, both anteriorly and posteriorly.

Results

<table>
<thead>
<tr>
<th>Mean Distance from Phys</th>
<th>All-Metaphyseal Tunnel Size</th>
<th>All-epiphyseal Tunnel (4mm)</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>5mm</td>
<td>6mm</td>
</tr>
<tr>
<td>8-11 yo</td>
<td>3.4mm</td>
<td>2.9mm</td>
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</tbody>
</table>

All drill tunnels were placed ≥2mm from the physis to avoid physeal injury due to heat friction.

The 3-D models illustrate 5mm, 6mm and 7mm all-metaphyseal tunnels as well as 4mm all-epiphyseal tunnels can be placed without direct injury to the proximal tibial physis.

Discussion

- For epiphyseal drilling, the margin of error for avoiding physeal injury is small, but this technique may better reproduce the broad PCL Attachment on the Tibia.
- Partial Length Tunnels may be considered to reduce the risk of Physeal Injury.

- Further Modifications to the all-epiphyseal tunnel may be considered to reduce the impact of the high ‘killer-turn’ angle on the tibia (as shown in Figure 2).

Fig 1: 10 year-old, male, right knee. (a) Sagittal view of a 7 mm, physeal-sparing all-metaphyseal tibial drill tunnel. (b) Sagittal view of a 4 mm, physeal-sparing all-epiphyseal drill tunnel.

Fig 2: 10 year old, male, right knee. 10 yo male, Right knee. Posterior (a) and posterioriomedial (b) views of a simulated PCL graft placed through an all-metaphyseal drill tunnel and anchored to the posterior epiphysis to reduce the “killer turn” effect.


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