Temperature Change When Drilling Near The Distal Femoral Physis In A Skeletally Immature Ovine Model

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Disclosures:
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Introduction: ACL injuries are being reported with increasing frequency in skeletally immature patients. Knee instability places a patient at risk for further damage to the menisci and articular cartilage. Therefore, these are often reconstructed. Numerous techniques for ACL reconstruction in the pediatric population have been described. One technique that is becoming more popular is an all epiphyseal technique. This technique is hypothesized to be less dangerous to the health of the physis, because it is a physis sparing technique. However, concerns regarding the risk of thermal injury from simply drilling near the physis have been expressed. 1 The purpose of this study was to determine whether drilling at or near the physis caused a temperature increase that could trigger chondrolysis.

Methods: Ten skeletally immature lamb femoral condyle specimens were randomly placed in each of six groups.
1) 8 mm acorn tipped; 3 mm from physis (n=10)
2) 8 mm acorn tipped; 0.5 mm from physis (n=10)
3) 10 mm acorn tipped; 3 mm from physis (n=10)
4) 10 mm acorn tipped; 0.5 mm from physis (n=10)
5) 8 mm FlipCutter; 0.5 mm from physis (n=10)
6) 10 mm FlipCutter 0.5 mm from physis (n=10)
A temperature probe was placed in the physis. A guide pin was inserted at an appropriate distance to leave a 0.5 mm or 3 mm distance from the top of the reamer to the bottom of the physis for either an 8 mm or 10 mm acorn tipped reamer. To test the FlipCutter, the device was placed at an appropriate distance to leave a 0.5 mm or 3 mm distance from the top of the reamer to the bottom of the physis for each reamer size. Each condyle was secured in a custom made box and placed in a saline bath at 37°C +0.1°. A drill press was used for drilling, and was set at 990 rpm. Temperature change at the distal femoral physis and drilling time were measured for each group. The assumptions of a one-way analysis of variance (ANOVA) were not met due to inequality of variances, so the analysis was conducted using a Kruskal-Wallis test (p < 0.05), which is the nonparametric alternative to the one-way ANOVA. In the case of a significant result for the Kruskal-Wallis test, pair-wise Mann-Whitney post-hoc tests were conducted to evaluate where the significant difference occurred.

Results: The temperature increased to 42.6°C using the 8 mm FlipCutter in one specimen (Table 1). The temperature did not increase above 39.5°C in any specimen at any time for the acorn tipped reamers. There was a significant difference among the four groups at 0.5 mm from the physis (p=0.001). Pairwise Mann-Whitney post-hoc tests were performed to evaluate the differences among the groups. The 8 mm FlipCutter had a significantly higher maximum temperature (39.8° +/- 1.4°) compared with the 10 mm FlipCutter (38.0° +/- 0.6°, p=0.001), 8 mm acorn tipped reamer (38.1° +/- 0.9°, p=0.007) and 10 mm acorn tipped reamer (37.5° +/- 0.3°, p<0.001). The maximum temperature was significantly higher for the 8 mm acorn reamer at 0.5 mm from the physis compared with 3 mm (37.3° +/- 0.3°, p=0.02). There was no significant difference in maximum temperature for the 10 mm acorn reamer when drilling 0.5 mm from the physis compared with 3 mm (p=0.301) (Table 1).

Discussion: To our knowledge, this is the first study evaluating the temperature at the physis when drilling in its proximity. We found that the acorn tipped reamer did not create a temperature increase in the physis above 39.5°C. However, this increase was higher for the FlipCutter device (a maximum of 42.6° C in one case). While the precise temperature that leads to injury or necrosis of chondrocytes is unknown, all known studies support maintenance of chondrocyte health when temperatures remain below 43°C.2 Benton et al. showed chondrocyte detachment and necrosis beginning at 43°C.3 Züger et al. revealed that chondrocyte death was initiated between 52-54°C, and most chondrocytes were dead when temperatures reached levels above 54°C.4 Our findings suggest the risk of thermal induced injury to the physis is very low with an all epiphyseal drilling technique using an acorn tipped reamer even if the drilling occurs very close to the physis. The FlipCutter device may have a slightly higher risk for thermal injury, however, only when drilling 0.5 mm from the physis.

Significance: Drilling near the femoral physis when performing an all epiphyseal ACL reconstruction should not cause thermal injury to this area when using an acorn tipped reamer. There may be a slight risk when using other devices.

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<table>
<thead>
<tr>
<th>Sample</th>
<th>8 mm acorn tipped</th>
<th>10 mm acorn tipped</th>
<th>8 mm FlipCutter</th>
<th>10 mm FlipCutter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm from physis</td>
<td>36.9</td>
<td>37.4</td>
<td>37.2</td>
<td>38.3</td>
</tr>
<tr>
<td>3 mm from physis</td>
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<td>37.7</td>
<td>37.0</td>
<td>38.5</td>
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<td>37.1</td>
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<tr>
<td>10</td>
<td>35.0</td>
<td>37.7</td>
<td>38.7</td>
<td>39.1</td>
</tr>
</tbody>
</table>

Average: 38.97 37.25 37.53 37.15 39.80 37.97
Std Dev: 0.90 0.32 0.57 0.19 1.44 0.55

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