Intercondylar Femoral Notch Preparation for Posterior Stabilized Knee Arthroplasty – Volumetric Bone Resection

Analysis According to Two Methods

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Introduction:
Since being introduced in 1978, posterior stabilized (PS) knee implants have become increasingly popular, and currently account for almost 50% of total knee arthroplasty (TKA) surgeries. A PS knee implant compensates for poor posterior cruciate ligament (PCL) function by using a tibial post and femoral cam mechanism to induce controlled and predictable femoral rollback. Implanting a PS femoral component requires surgeons to create an intercondylar notch to accommodate the cam housing, which requires a resection volume that varies depending on prosthesis design.1 Recently, PS implants with high-flexion (HF) capability have been introduced to maintain a large contact area under deep flexion. However, HF implants may require larger post/cam mechanisms to handle the shear load associated with deep flexion, which can increase the resection volume required to make the intercondylar notch. The purpose of this study was to evaluate volumetric bone resection associated with three PS prostheses (two HF and one standard) from the same family of knee implants, prepared according to the appropriate technique associated with each implant. One method used a conventional notch guide (NG) while the other used a newly introduced reamer guide (RG).

Materials and Method:
Three PS knee implants from the Optetrak family (Exactech, Gainesville, FL, USA) were considered for this study (see Table I).

Table I: Implant list

<table>
<thead>
<tr>
<th>Implant</th>
<th>Size</th>
<th>HF Capability</th>
<th>Method of Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optetrak RG</td>
<td>3</td>
<td>Yes</td>
<td>RG</td>
</tr>
<tr>
<td>Optetrak PS</td>
<td>3</td>
<td>No</td>
<td>NG</td>
</tr>
<tr>
<td>Optetrak HF</td>
<td>3</td>
<td>Yes</td>
<td>NG</td>
</tr>
</tbody>
</table>

The Optetrak RG, which is a new HF design, distinguishes itself from the Optetrak PS and HF by a characterized rounded PS housing intended to be prepared using the RG (i.e., reaming; Figure 1-RG) (rather than a rectangular box prepared by using a conventional NG (Figure 1-NG)).

Results:
There was no statistical difference between the two surgeons (p>0.05). The differences in bone resection volume between the three PS implants were all significant. Average bone resection volumes for the Optetrak RG, PS, and HF were 5.30 ±0.26 cm³, 6.14 ±0.82 cm³, and 7.50 ±0.59 cm³, respectively. Finally, the standard deviation associated with the RG method is lower than that of the conventional NG method (Figure 2). This result demonstrates a higher predictability for the RG method.

Discussion:
Despite the high success rates of TKA, there is still controversy regarding removal versus retention of the PCL. The proponents of cruciate retaining designs believe that it is important to retain as much of the original anatomy as possible, and that the PCL can continue to stabilize the knee during flexion. However, PS designs offer potential advantages such as a more stable component interface, a less technically demanding procedure, and increased range of motion.

One established goal of TKA is to preserve patient bone stock. Therefore, providing a PS implant with a minimum intercondylar notch resection should be a design objective. Based on a previous study comparing several implants available to the market, Haas et al. demonstrated the Optetrak PS was associated with the smallest bone resection (6.8 cm³) among the other systems when a small size of bone (Optetrak size 2) was considered. Their bone resection volume is relatively close to the one measured through the present study using a size 3 bone. However, it should be noted that the bone resection volume is greatly dependent on the bone size and the geometry of the native intercondylar notch, and, as a result, comparison between the two studies is limited.

The use of a CNC-machined distal femur and the accurate placement of the cutting guide according to the ML axis provided consistency for all the experiments and allowed a direct comparison of the bone resection volume among the three considered PS implants, as well as the two methods of preparation. The Optetrak HF required a higher bone resection volume than the Optetrak PS using the same NG technique in order to accommodate a more prominent PS housing. Due to a rounded PS housing, easily prepared with the RG method, the Optetrak RG enables the association of the HF range of motion with a bone-sparing approach.

References:

Figure 1: Appropriate cutting guide was placed at a defined location from the medio-lateral (ML) reference plane to ensure consistency for both methods
A mid-size distal femur (Zygote Solid Skeleton, Zygote, American Fork, UT) was modeled in CAD (UG NX6, Siemens, Plano, TX) to include the five femoral finishing cuts. Thirty distal femurs were CNC machined out of polyurethane foam conforming to ASTM F1839. A number from 1 to 30 was randomly assigned to each machined distal femur and a fellow orthopedic surgeon prepared intercondylar notches of five distal femurs for each implant type according to the respective technique. For each femur the plane of symmetry was located 4.24 cm from the reference plane located on the lateral epicondyle (Figure 1). This ensured each intercondylar notch resection was performed at the same location relative to the native intercondylar notch for all the tests specimens. Next, the pins and the cutting guide were removed. The mass (m) of each foam knee was measured using a scale with a resolution of ± 10µg (XP 205, Mettler Toledo, Columbia, MD).

The volumetric bone resection was calculated from the mass difference (i.e., m₁-m₂) divided by the foam density (d= 0.490 g/cm³).