Influence of a Secondary Downsizing of the Femoral Component on the Extension Gap: A Cadaveric Study

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abstract

The purpose of this study was to evaluate the effect of a secondary reduction of the femoral component size on flexion and extension gaps intraoperatively in posterior-stabilized total knee arthroplasty (PS-TKA) monitored by computer-assisted surgery. The authors hypothesized that cutting additional bone on the posterior femoral condyle may increase the extension gap due to the posterior capsule and soft tissue loosening.

Reduction of the femoral component size was performed by additional 4-in-1 cuts after the PS-TKA on 15 cadaveric knees using a ligamentous tension device with the aid of computer-assisted surgery. Measurements of the medial and lateral flexion gaps, as well as the medial and lateral extension gaps, were recorded before and after reducing the femoral component size. Trial components were used from a mobile-bearing total knee system.

After reducing the femoral component size, the medial and lateral flexion and extension gaps measured larger than their initial size. The mean increases of the medial extension and flexion gaps and the lateral extension and flexion gaps were 1.3 ± 0.9, 1.0 ± 1.2, 1.1 ± 1.2, and 1.3 ± 1.3 mm, respectively; all 4 differences were significant (P < .05). Surgeons should be aware of the effect of downsizing components intraoperatively because it might lead to an extension laxity. Thus, a downsizing of the femoral component may compromise the postoperative stability of TKA.

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Total knee arthroplasty (TKA) has proven to be successful in the treatment of primary and secondary osteoarthritis of the knee. Previous studies have shown highly satisfactory outcomes and long-term survival rates of components. The success of TKA is strongly dependent on a precise mechanical alignment and knee stability in flexion and extension.

Preparing equal soft tissue loosening. The purpose of this study was to evaluate the effect that a reduction in the size of the femoral component would have on the extension gap in posterior-stabilized TKA.

After the performance of all bone cuts, proportions of the femoral trial components could protrude over the bone, particularly in a mediolateral dimension. However, the selected implant may also be too large in relation to the anatomical position in the anteroposterior dimension, which is visible through inconsistently prepared bone surfaces, and not allow for a balancing of the flexion and extension gaps. In these situations, it is sometimes necessary to further reduce the femur size intraoperatively. If one were to solely take the repeat resection of the bony surfaces into consideration, theoretically only an opening of the flexion gap would exist; however, the repeat bone resection would have no influence on the extension gap because the distal femur cut does not have to be changed.

However, in the current authors’ experience, after reducing the size of the femoral component by cutting more of the posterior femoral condyles due to the anterior reference for the secondary positioning of the 4-in-1 cutting block, a laxity of the extension gap is observed. This is due to inconsistencies in the anterior reference, which is not always possible to maintain the anterior reference, a new anterior reference for the secondary positioning of the 4-in-1 cutting block could be used.

A PS-TKA was performed on 15 normal knees of 8 cadavers, and the static extension and flexion gaps were measured using computer-assisted surgery. Each gap parameter was compared before and after reducing the size of the femoral component. None of the cadaver knees had scars or previous surgery; they had a full range of motion and no gross abnormalities of alignment. One knee was excluded due to a nonunion of the hip.

All procedures were performed by the senior author (P.S.). A midvastus approach was used through a midline skin incision. After arthrotomy and the presentation of the knee joint, the tracker screws for the computer-assisted surgery were attached with a bicortical screw to the tibia and femur, respectively. The tracker screws were placed on the medial tibial crest outside the arthrotomy using a 2-cm incision and the femoral crest in the proximal end of the arthrotomy. A step-by-step registration process was performed using OrthoPilot TKA 4.3 software with a computed tomography–free navigation system (B. Braun Aesculap, Tuttingen, Germany). The proximal tibial bone cut was first performed with a posterior slope of 0°. The tibial implant (e.motion; B. Braun Aesculap) contains a posterior slope of 3°.

In the next step, the ligamentous tension in extension and flexion was applied for the preoperative planning of the femoral component. After the gap balancing was performed, the proper size and rotation of the femoral component were determined. After this, the femoral finishing bone cut was made. All cadaver knees received the trial femoral component, and the static extension and flexion gaps were recorded. The anteroposterior size difference between adjacent component sizes inside the component is consistent at 3 mm. However, the thickness of the material is different. Sizes 2 and 3 have a thickness of 7 mm, whereas sizes 4 to 6 have a thickness of 8.5 mm and all larger sizes have a thickness of 10 mm.

In the next step, the size of the femoral component was reduced by 1 size by resecting the posterior femoral condyle using a 4-in-1 cutting block. However, to maintain the anterior reference, a new hole was drilled for cutting the posterior and posterior chamfer. Finally, the newly sized trial femoral component was inserted, and the static extension and flexion gaps were measured and recorded.

The patella was subluxated after placement of the femoral trial component. Computer-assisted surgery was used to set the knee position to 0° extension and 90° flexion before the gap measurements were taken, including those for the medial extension gap, the lateral extension gap, the medial flexion gap, and the lateral flexion gap (Figure 1). The double-piston tension device (Knee Balancer; DePuy, Warsaw, Indiana) was used to maintain constant
pressure and set the tension to 98 N for a proper gap evaluation\(^9\) (Figure 2A). In addition to a measurement of the 90° flexion gap, the hip joint was flexed to negate the gravitational effect from the thigh (Figure 2B). After the femoral component was downsized, the gap measurements were recorded using the same process.

Data were analyzed using SPSS version 17 software (SPSS Inc, Chicago, Illinois). Descriptive results of continuous variables were expressed as mean ± SD. The paired t test was used for comparing intergroup data. A P value less than .05 was set as statistical significance.

### RESULTS

Seven male and 1 female cadavers with a mean age of 59 years (range, 45-72 years) were used for the study. With regard to the initial size of the femoral component, 3 size 4, five size 5, and 7 size 6 components were used. After reducing the femoral component by 1 size (Table), the authors found that the flexion and extension gaps were larger than their initial size. The mean increases of the 90° flexion gap on the medial and lateral sides after downsizing the femoral component were 1.0 ± 1.2 mm (range, 0.0 to 4.0 mm) and 1.3 ± 1.3 mm (range, −1.0 to 3.0 mm), respectively. Similarly, the mean increases of the 0° extension gap on the medial and lateral sides after downsizing the femoral component were 1.3 ± 0.9 mm (range, 0.0 to 3.0 mm) and 1.1 ± 1.2 mm (range, −1.0 to 3.0 mm), respectively.

With regard to the correlation between different sizes of the femoral component, the results showed that both the extension and flexion gaps significantly increased after downsizing the femoral component (\(P \leq .05\)). However, no significant difference existed between the medial and lateral side of the flexion and extension gap differences (\(P > .05\)).

### DISCUSSION

In certain situations, an anteroposterior and mediolateral mismatch of the distal femoral condyles leads to the decision to reduce the femoral component size. In this technique, more of the posterior femoral condyle is resected than the anterior part of the bone to prevent anterior femoral notching. However, this posterior resection resulted in an increase in the flexion gap.\(^7,8,10\) Moreover, it was observed that the effect of joint laxity can also occur in the extension gap. To prove this hypothesis, a cadaveric laboratory setup was chosen to examine the effect of reducing or downsizing the femoral components. In addition, this study used posterior referencing as the major focus; the anterior referencing is only incorporated for the secondary focus of downsizing the femoral component to avoid a notching of the anterior femoral corticalis.

Navigation systems have been developed to more accurately achieve ligamentous balancing and optimized component positioning.\(^11-14\) Some systems comprise soft tissue and gap balance features. In the current study, OrthoPilot TKA 4.3 software was used because it can measure the

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**Table**

<table>
<thead>
<tr>
<th>Gap Measurement</th>
<th>Initial Femoral Size, mm</th>
<th>After Reduced Size, mm</th>
<th>Gap Difference, mm</th>
<th>(P^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>(P)</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Medial flexion</td>
<td>11.0 ± 4.6</td>
<td>12.0 ± 4.7</td>
<td>&lt;.001</td>
<td>1.0 ± 1.2</td>
</tr>
<tr>
<td>Lateral flexion</td>
<td>15.8 ± 3.9</td>
<td>17.1 ± 4.4</td>
<td>.003</td>
<td>1.3 ± 1.3</td>
</tr>
<tr>
<td>Medial extension</td>
<td>8.6 ± 2.9</td>
<td>9.9 ± 3.3</td>
<td>.006</td>
<td>1.3 ± 0.9</td>
</tr>
<tr>
<td>Lateral extension</td>
<td>12.4 ± 2.8</td>
<td>13.5 ± 3.1</td>
<td>.002</td>
<td>1.1 ± 1.2</td>
</tr>
</tbody>
</table>

*Medial/lateral.*
flexion and extension gaps on the medial and lateral sides after the femoral component has been inserted. Moreover, this system can detect small changes in gaps, as well as angular changes.

Although some reports showed different results when measuring gaps with or without a trial femoral component in place, the current study was designed to use the trial femoral component in place to reflect an actual TKA and flex the hip while measuring the 90° flexion gap to eliminate a gravitational effect from the thigh. This study confirmed the results of previous studies that more posterior bone resections or a reduction or downsizing of the femoral component can affect the increase of the flexion gap distance on the medial and lateral sides (medial flexion gap, 1.0±1.2 mm; lateral flexion gap, 1.3±1.3 mm; \(P<.05\)). In the same way, the results show a significantly increased extension gap on the medial and lateral sides (medial extension gap, 1.3±0.9 mm; lateral extension gap, 1.1±1.2 mm; \(P=0.0\)). Joint laxity presented no difference on both sides in each gap (\(P=0.0\)). The authors assume that the increase of the extension gap was caused by a bow string effect or a loosening of the posterior structure. However, with this result, a 1-mm difference may be difficult to perform in an operation that is not merely an osteal procedure but also relies heavily on ligamentous balancing. This study solely focuses on determining whether accepted theory is correct in asserting that an additional resection of the posterior condyle solely has an opening influence on the flexion or whether the extension could also be influenced by the changed tension in the capsular structure.

One limitation in this study was a small knee size (femoral size below 3) that did not pass through the tension device. No initial femoral component was found in size 3. In addition, this study used a normal fresh cadaver and, therefore, some procedures did not directly correspond with the clinical situation. The ligamentous behavior is different for osteoarthritis patients.

**Conclusion**

When the size of the femoral component was reduced, it caused an increase of laxity in the flexion and extension gaps due to cutting the posterior bone and soft tissue tightness or tension effects. Surgeons should be aware of the effect of downsizing intraoperatively because it may lead to an extension laxity. Thus, downsizing the femoral component may compromise the postoperative stability of TKA. Further examination of a larger sample size is planned to confirm these results.

**References**


