A Lateralized Anterior Flange Improves Femoral Component Bone Coverage in Total Knee Arthroplasty

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Introduction: Femoral components with narrower mediolateral (ML) dimensions recently have been used clinically to avoid ML overhang for narrow-shaped femurs in total knee arthroplasty (TKA). There have been reported a wide variety of ML overhang rates when using standard TKA components in female knees, from 7.5% to 68%. Furthermore, component overhang is affected by implant design and surgical factors, patient gender, and probably race and lifestyle factors. There have been recent reports about detailed femoral component fit and bone over-/under-coverage. In all cases, there are clinical concerns when the femoral component overhangs the bone and risks soft-tissue interaction, or when the implant does not cover cut bone and risks increased postoperative bleeding, or development of heterotopic bone.

The purposes of this study are to simulate TKA in Japanese varus osteoarthritic knees, to determine the detailed overhang and underhang rates and bone widths in each portion of the distal femur by gender, and to determine if it is necessary to use narrow femoral component or to further modify the femoral component shape to optimize prosthetic coverage of bone.

Methods: Preoperative computed tomography (CT) scans of the whole lower-extremity (including hip and ankle joints) were obtained from 100 females and 50 males undergoing TKA. The program 3D Template (Kyocera Medical, Osaka, Japan) was used for TKA simulation and Bi-Surface 5 implants (Kyocera Medical, Osaka, Japan), including standard and narrow width femoral components, were virtually implanted.

1. Simulation of the femoral component
Femoral coronal alignment was set perpendicular to the mechanical axis of the femur. The planned sagittal alignment was set parallel to the anatomical axis of the distal femur to avoid notching of the femur due to its anterior bowing. The rotational alignment was adjusted to the surgical epicondylar axis. We adjusted the size of the femoral component to be as close as possible to the lateral width of the posterior condyles. The ML position was set to minimize overhang and underhang to the extent possible.

2. Measurements of the overhang and underhang
We focused on the following four zones of the femoral component; Antero-Proximal (Ant-Prox) zone, Antero-Distal (Ant-Dist) zone, Postero-Distal (Post-Dist) zone and Postero-Proximal (Post-Prox) zone (Fig. 1). First, we selected one of the standard or narrow femoral components which best fit the femur bone without excessive overhang. Second, the narrow component was aligned and the amount of overhang or underhang were measured in the medial or lateral portions of the four zones described above. “Positive” overhang / underhang measures were defined as overhang or underhang greater than 2 mm
in each zone. Knees with at least one positive overhang measure were defined as overhang positive knees. Finally, the standard component was aligned and the overhang or underhang was measured in the same manner. Overhang width is described with positive values and underhang is described with negative numerical values.

Fig. 1 Four zones of the femoral component
1. Ant-Prox zone
2. Ant-Dist zone
3. Post-Dist zone
4. Post-Prox zone

**Results:** The narrow femoral component was selected in 83% of female knees and 36% of male knees. When the standard component was aligned, overhang was observed in 69% of female knees and 20% of male knees.

When the narrow component was aligned in female knees, almost all of the overhang cases occurred in the Ant-Prox medial region (Fig. 2). Concomitantly, underhang in the Ant-Prox lateral region occurred frequently with overhang in the Ant-Prox medial portion despite the fact the femoral bone width in the Ant-Prox zone was as same as the implant component width. Underhang was observed in all other zones except the Ant-Prox zone, especially in the medial portions.

When the standard component was aligned in male knees, the same results as described above were observed.

Fig. 2 Overhang / underhang rate and width with the narrow component in female knees.

**Discussion:** The narrow femoral component will help avoid or minimize overhang in most female and some male knees. Although the width of the narrow femoral implant in the Ant-Prox zone closely matched the female bone width, the femoral component was displaced laterally to avoid overhang in the Ant-Prox medial portion (Fig. 3-A). As a result, there was significant underhang in the medial portions of the distal and posterior zones. When the component was centered in the distal and posterior zones, 2-2.5 mm overhang was observed in the Ant-Prox medial zone (Fig. 3-B). Therefore, it would be ideal to shift the anterior femoral flange laterally 2-2.5 mm on average relative to the distal and posterior aspects (Fig. 3-C). This modification might allow the surgeon to select a femoral component with a little bit wider ML dimensions in the distal and posterior aspects to minimize the observed underhang, but only if overhang of the anterior aspect is eliminated (Fig. 3-D).

When we compared the component used in this study with other major prostheses having narrow ML options, the position of the anterior aspect relative to the distal and posterior aspects was similar. Therefore, the modifications described above might be useful for many commercially available prostheses to optimize bone coverage.

Fig. 3 Schemas of the prosthetic coverage with the narrow component in female knees. Black solid lines and the blue figure indicate the bone width of each zone and the narrow component, respectively. (A) When aligned to fit the anterior aspect. (B) When aligned in the center of distal and posterior zones. (C) Combination of the anterior aspect of A and the distal and posterior aspects of B (green line). (D) Combination of the anterior aspect of A (green line) and the distal and posterior aspects of the standard component (purple line).
Significance: Narrow femoral components may help to avoid implant overhang in TKA. Ideally, the anterior femoral flange would be shifted 2-2.5 mm laterally relative to the distal and posterior aspects to provide optimal bone coverage of the femoral component on the resected femur.
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2-2.5 mm medialization

(fitting the anterior aspect)

(aligning in the center)