Impact of Intramedullary Reaming Depth on Establishing Femoral Canal Axis in the Sagittal Plane

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Introduction: Femoral intramedullary (IM) diaphyseal fixation with press-fit stems improves the clinical outcomes of revision total knee arthroplasty (RTKA) [1,2]. It is standard clinical practice to use progressive reaming to prepare the canal to receive the stem extension, while the surgeon determines the appropriate reaming depth based on patient anatomy, degree of femoral bowing, and type of stem used. There are two philosophies for reaming depth, including: 1) plunging the reamer deeply into the IM canal (submerging the cutting flutes), and 2) reaming just to the anticipated proximal location of the stem extension tip. However, little quantitative information exists on the impact of reaming depth on stem fit and sagittal alignment of the femoral component. This study simulated IM reaming in the femur using a set of pre-defined reamer geometries, to investigate stem fit, canal diameters, and the impact of femoral bowing on the sagittal IM canal axis at multiple press-fit levels.

Methods: A set of cylindrical reamer surface models (diameters starting from 10mm with 1mm increments) were used to virtually ream the IM canals of 187 healthy right femora with functional anterior-posterior dimensions (FAP, distance from anterior cortex to the plane tangent to the posterior condyles) between 55mm and 59mm. By minimizing the distance from the distal (10-20mm) reamer surfaces to the internal cortex, the virtual reaming algorithm maximizes reamer diameter while optimizing its engagement with the inner diaphysis (Fig. 1A) at three depths (100, 150, and 200mm). In cases where a reamer with diameter less than 10mm is required for a specific target depth, the reaming depth was shortened at 5mm intervals until the canal was able to accommodate the smallest diameter reamer. The three resultant IM canal axes established by reaming to the specified depths were compared to the mechanical axis for sagittal alignment. The differences in the anterior-posterior (AP) locations of the resultant canal distal entry points were also assessed. Sagittal bowing of the femur was calculated as the angle between two localized diaphyseal canal axes, defined as the fitted lines through 5 largest inscribed circles evenly sampled on each of the two inner cortex regions, located at 80 to 130mm and 150 to 200mm proximally from the distal femur (Fig. 1D). The impact of bone bowing on reaming was also
investigated.

**Results:** All the femora were able to be reamed to 100mm. However, 6.9% of the femora could not be reamed to 150mm and 43.0% could not be reamed to 200mm. The femora that could be reamed to 200mm were more likely to experience significant bowing than femora that could only be reamed to shorter depths (p=0.04). A summary of sagittal angle between the mechanical axis and canal axes based on specified reaming depths is presented in Fig. 2A. Overall, deeper reaming reduced the angular deviation between the resultant canal axis and the mechanical axis (Fig. 1B, 2A), with significant higher deviation in 100mm reaming than 150mm and 200mm reaming (p<0.01). Increased reaming depth led to an anterior shift of the canal axis entry point (Fig. 1C, 2B). The distal bow of the femur affects both the distal entry point of the reamer and angular deviation between the canal and the sagittal mechanical axis (Fig. 2).
Discussion: The study emphasizes the importance of reaming to an adequate depth to achieve diaphyseal engagement when using press fit stem extensions. Shorter reaming depth may lead to inadequate fixation if a press-fit is not achieved and/or there is incorrect alignment with a flexed femoral component. The results also suggest that more anterior entry point is needed for deeper reaming to facilitate insertion of the reamer into the IM canal, especially for bowed femora. These data can benefit implant component design and reaming techniques to achieve better diaphyseal fixation and proper sagittal alignment during RTKA.

Significance: Shorter reaming depth may lead to inaccurate intramedullary canal axis identification in the sagittal plane when using a press fit stem during revision total knee arthroplasty. Reaming depth and the distal bow of the femoral diaphyseal canal can impact both orientation and entry point of the IM canal.

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