Femoral Bowing is Main Determinant of the Proper Alignment to Restore Mechanical Axis in Total Knee Arthroplasty

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Introduction: Successful knee replacement surgery improves quality of life for hundreds of thousands of patients every year in the United States. Success is dependent on proper restoration of the alignment of the leg. The proper angle at which the surgeon should cut the distal femur (Valgus Cut Angle, VCA) cannot be easily determined. Conventional thinking is that the VCA is depends on femoral length or femoral offset. The proper VCA to restore alignment depends on anatomic factors of the femur that have not been previously elucidated. The effect of femoral bowing on the VCA has not been previously studied. We sought to determine the incidence of femoral bowing and influence on VCA. We hypothesized that femoral bowing has a strong effect on the VCA necessary to restore physiologic alignment after arthroplasty or osteotomy.

Methods: A total of 102 long-leg radiographs (51 inches) were obtained from patients scheduled for total knee arthroplasty. The patients on average were 41% male 59% female, 67.9 ± 11.1 years, 67.0 ± 4.7 in, 192 ± 43 lbs, and had a BMI of 29.7 ± 4.8. All radiographs were prepared with the feet placed in identical rotation and the patellae pointing forward. Any radiograph that appeared malrotated was excluded. This was defined as >3mm difference in head offset of the right and left femur, a difference in the width of the tibiofibular syndesmosis, or a difference in the rotation of one foot compared to the other.

The following anatomic variables were measured on each radiograph using published methods: (i) the neck shaft angle (NSA), (ii) the length of femur, (iii) the length of the femoral shaft, (iv) the medial head offset, (v) the medial-lateral bow of the distal femur, (vi) the hip-knee axis angle, (vii) the mechanical axis deviation of the extremity at the knee, (viii) the medio-lateral bow of the tibia, and (ix) the valgus cut angle required to restore the mechanical axis to the center of the knee during surgery (VCA).

Bivariate plots were constructed using the measurements thought to influence the VCA: femoral bowing, femoral offset, and length of femur. A linear regression was then performed yielding Pearson’s coefficient. Pearson’s coefficient was then used to calculate a p-value. A multivariate regression was then used to find the variable that had the strongest effect on the VCA.

Results: A histogram of femoral bowing was constructed from all cases to view the frequency (Figure 2). The bivariate plot of offset and VCA yielded an R2 of 0.02544 (p = 0.11) demonstrating statistically insignificant correlation between the two. The bivariate plot of femoral length and VCA yielded an R2 of 0.1294 (p = 0.0002) showing statistically significant correlation. Lastly, the bivariate plot of femoral bowing and VCA yielded an R2 of 0.59136 (p < 0.0001) showing statistically significant correlation (Figure 3). Multivariate analysis revealed that femoral bowing was the best predictor of VCA: VCA =
5.46-0.363 femoral bowing (°) + 0.106 Femoral offset (mm) - 0.010 femoral length (mm). Figure 1 shows examples of femurs with significant bowing.

**Discussion:** Currently, surgeons choose the valgus angle of the distal femoral osteotomy (VCA) on the basis of population averages (typically 5 degrees), or use binary values on the basis of each patient’s height or femoral offset. Clinicians performing knee replacements typically do not consider femoral bowing when selecting the valgus angle appropriate for each patient. Our work demonstrates that femoral bowing has a potent effect on VCA. The multivariate regression indicated that femoral bowing had the highest effect on VCA followed by offset and femoral length. The other variables measured did not influence the VCA. Surgeons should consider measuring long alignment radiographs before performing a total knee arthroplasty.

**Significance:** Accounting for femoral bowing in the calculation of the VCA allows the surgeon to better restore proper alignment when performing TKA.
Figure 2. Histogram showing the observed frequency of values of the femoral bow angle
Figure 3. Bivariate plot showing the distribution of values of the VCA vs. Femoral Bowing.

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