

Progressive Femoral Bowing and Varus Alignment over Ten Years after Total Knee Arthroplasty

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INTRODUCTION: The advantages and disadvantages of personalized alignment in total knee arthroplasty (TKA) have been widely discussed. Some surgeons aim to restore constitutional alignment to provide a more natural postoperative feeling; however, this approach may result in varus alignment in patients with constitutional varus. Although a small degree of varus does not appear to compromise implant longevity in modern TKA, excessive varus should be avoided.

Age-related deformities such as femoral lateral bowing and proximal tibial varus are well recognized, and these changes may occur even after TKA. While implant positioning relative to bone has been studied, postoperative morphological changes in bone structure remain unclear. This study aimed to evaluate long-term changes in femoral and tibial morphology, as well as lower limb alignment, following TKA.

METHODS: We reviewed 417 patients who underwent mechanically aligned TKA between 2008 and 2015. Among them, 175 lower limbs with available anteroposterior whole-leg standing radiographs both immediately postoperatively and at ≥ 10 years postoperatively were identified. Fifty-seven limbs were excluded due to additional ipsilateral or contralateral lower limb surgery (THA, femoral intramedullary nailing, etc.), and 12 limbs were excluded due to malrotated radiographs. A total of 106 lower limbs (78 bilateral and 28 unilateral TKAs) were analyzed (20 males and 86 females). Radiographic parameters—including the hip–knee–ankle (HKA) angle, femoral bowing angle, lateral distal femoral angle (LDFA; angle between distal femoral axis and implant surface), joint line convergence angle (JLCA), medial proximal tibial angle (MPTA; angle between proximal tibial axis and implant surface), and tibial bowing angle—were compared using paired t-tests. Correlations between changes and contralateral/ipsilateral parameters were also assessed.

RESULTS: The mean age at surgery was 70.0 years, and 86 patients were female. Diagnoses included osteoarthritis (n = 77) and rheumatoid arthritis (n = 29). The mean follow-up was 10.5 years.

The mean HKA angle shifted from $0.3^\circ \pm 3.5^\circ$ valgus to $1.9^\circ \pm 3.5^\circ$ varus ($p < 0.001$), and the lateral femoral bowing angle increased from $2.4^\circ \pm 4.6^\circ$ to $4.5^\circ \pm 5.1^\circ$ ($p < 0.001$). The lateral femoral bowing angle increased by 3° – 6° in 30 limbs (28.3%) and by $>6^\circ$ in 7 limbs (6.6%) (Figure 1). The MPTA decreased from $88.7^\circ \pm 4.3^\circ$ to $87.7^\circ \pm 4.4^\circ$ ($p = 0.03$). In contrast, no significant changes were observed in LDFA (81.5° to 80.8°), JLCA (0.3° to 0.4°), or tibial bowing angle (0.7° to 0.5°).

Progression of femoral bowing was significantly correlated with the initial contralateral HKA angle ($r = 0.31$, $p = 0.02$), but not with ipsilateral HKA, MPTA, tibial bowing, or JLCA (Table 1).

DISCUSSION: This is the first study to demonstrate that progressive femoral bowing is the primary contributor to varus progression after TKA. These findings suggest that age-related morphological changes of the femoral shaft continue even after TKA. Notably, more than 30% of femora showed an increase in lateral bowing of $>3^\circ$.

Other potential causes of alignment change include implant subsidence and lateral soft-tissue elongation. However, in this study, femoral component subsidence and ligament elongation likely had little effect because LDFA and JLCA did not change significantly. The MPTA decreased slightly but significantly, which may reflect either implant subsidence or age-related proximal tibial changes. Tibial bowing remained unchanged, consistent with reports in the general population.

The influence of postoperative alignment on morphological changes remains unclear. In this study, ipsilateral alignment did not affect outcomes, whereas contralateral alignment correlated with femoral bowing progression. One possible explanation is that mechanical alignment prevented excessive varus postoperatively, whereas contralateral alignment varied widely due to inclusion of osteoarthritic knees.

SIGNIFICANCE/CLINICAL RELEVANCE: Age-related morphological changes, particularly progressive femoral bowing, should be considered in preoperative planning, especially in patients with contralateral varus alignment.

Figure 1. Changes in Lateral femoral bowing

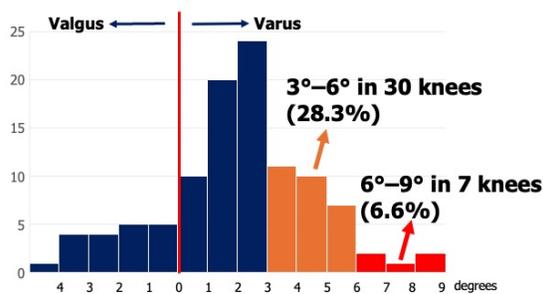


Table 1. Factors which were associated with delta femoral lateral bowing

	Ipsilateral						Contralateral
	Femoral lateral bowing	mLDFA	MPTA	Tibial lateral bowing	JLCA	HKA	HKA
Pearson r	-0.07	0.15	0.16	-0.05	0.05	0.04	0.31
95% CI	-0.26 to 0.12	-0.04 to 0.34	-0.03 to 0.34	-0.14 to 0.24	-0.15 to 0.23	-0.15 to 0.24	0.12 to 0.50
P value	0.45	0.23	0.10	0.66	0.61	0.65	0.002