

The Impact of Osteoarthritis on Joint Line Obliquity (JLO): A Comparison of CPAK and JLO Between Patients' End-Stage Osteoarthritic and Contralateral Healthy Knee Joints

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Introduction: Surgical alignment strategy in total knee arthroplasty (TKA) remains a topic discussion, especially as kinematic alignment (KA) introduces the theory that not all knees should be neutrally aligned, but instead restored to their native knee alignment. The Coronal Plane Alignment of the Knee (CPAK) uses Joint Line Obliquity (JLO) and the arithmetic Hip-Knee-Ankle angle (aHKA) to define nine different phenotypes of the knee [1]. Arthritis can lead to the development of osteophytes, cartilage loss, joint space narrowing, and possible subchondral collapse, each of which may have an impact on the overall alignment and therefore CPAK classification of the knee. The primary objective of this study is to determine the impact of osteoarthritis (OA) on knee alignment by comparing the JLO, aHKA, and CPAK classification of end-stage osteoarthritic knees to the contralateral healthy knee in the same patient.

Methods: We conducted a retrospective review of 578 patients who presented for TKA to a single surgeon from January 2021 to December 2023. Through radiographic review, patients were included if their operative knee had a Kellgren-Lawrence Classification (KL) of 4 in one (arthritic) knee and a KL grade 0 or 1 in the contralateral (healthy) knee. Weight-bearing long-leg radiographs were analyzed to determine CPAK classification, JLO, mechanical and anatomic lateral distal femoral angles (mLDFA, aLDFA), and medial proximal tibial angle (MPTA). Arithmetic HKA was defined as MPTA minus mLDFA (neutral: 0° ± 2°), while JLO was defined as mLDFA plus MPTA (neutral: 180° ± 3°), using established radiographic conventions. Intra-rater reproducibility was assessed with intraclass correlation coefficients (ICC). Absolute differences were summarized across the cohort using both mean ± standard deviation (SD) and median with interquartile range (IQR) to provide overall population-level differences. Secondary outcome measurements were analyzed using the Wilcoxon signed-rank test.

Results: The final study cohort included 90 patients. The mean age was 68.3 ± 10.5 years, 49% were female, and 66% had right operative knees with severe osteoarthritis. Patients were categorized by arthritis location as diffuse (n=6), lateral (n=16), or medial (n=68). Lateral OA was associated with increased valgus alignment (aHKA mean 6.6° vs. 2.4°, p < 0.05, Wilcoxon test), while medial OA showed greater varus alignment (-2.7° vs. -0.3°, p < 0.05). For JLO, lateral OA knees measured 175.7° ± 3.7 (mean ± SD) operative vs. 175.0° ± 3.8 non-operative (p < 0.05) vs. , while medial OA knees measured 173.3° ± 3.3 operative vs. 173.6° ± 3.3 non-operative (p > 0.05). Absolute side-by-side differences between operative and non-operative knees averaged 1.7° for LDFA, 2.3° for MPTA, 2.2° for JLO, and 3.5° for aHKA. Intra-rater reproducibility (ICC) ranged from 0.80-0.92.

Discussion: End-stage osteoarthritis alters LDFA, MPTA, and therefore JLO, aHKA, and CPAK classification compared with contralateral healthy knees. These results highlight the limitations of using arthritic knees to estimate native alignment, as remodeling can distort knee alignment. This underscores the need for careful consideration of alignment strategies in TKA, especially in severely arthritic populations, as reliance on arthritic measurements alone may lead to inaccurate restoration of native knee alignment.

Significance/Clinical Relevance: Knee alignment is distorted by end-stage arthritis, affecting CPAK classification and limiting the accuracy of using arthritic knees to estimate native alignment. Recognizing these limitations is necessary for preoperative planning for TKA.

References: [1] MacDessi SJ, Griffiths-Jones W, Harris IA, et al. Coronal Plane Alignment of the Knee (CPAK) classification. Bone Joint J 2021; 103-B: 329-337.

Images and Tables:

Absolute side-by-side differences

Characteristic	Mean ± SD	Median (IQR)
	N = 90 ¹	N = 90 ²
ΔLDFA (Non-op – Op)	1.7 ± 1.5	1.6 (0.6, 2.5)
ΔMPTA (Non-op – Op)	2.3 ± 2.1	1.7 (0.8, 3.3)
ΔJLO (Non-op – Op)	2.2 ± 1.7	2.0 (0.8, 3.3)
ΔaHKA (Non-op – Op)	3.5 ± 3.1	3.1 (1.3, 4.8)

¹ Mean ± SD
² Median (Q1, Q3)

Table 1. Absolute side-by-side differences (measured in degrees) between the arthritic (operative) and non-arthritic (non-operative) knees, reported as mean ± SD and median (IQR), irrespective of arthritis location.

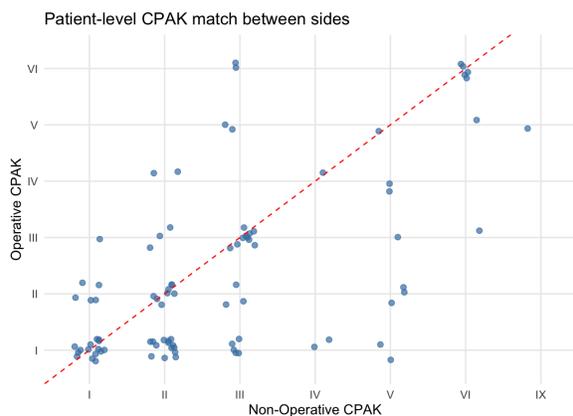


Figure 1. Patient-level comparison of CPAK classification between the arthritic (operative) and non-arthritic (non-operative) knees. The dashed line indicates identical CPAK classification between sides.

