Preservation of Joint Line Obliquity (JLO) May Influence Short-Term Outcomes, but Coronal Alignment changes Do Not Affect Three-Year Results After Mechanical Alignment TKA

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INTRODUCTION: Total knee arthroplasty (TKA) has demonstrated a long-term success rate of approximately 96% [1], although patient satisfaction remains around 80% [2]. Mechanical alignment total knee arthroplasty (MA-TKA), which aims to achieve a neutral hip–knee–ankle angle (HKA), has been widely adopted. However, only about 5% of native knees are truly neutral [3], and it has been hypothesized that patient dissatisfaction may arise from forcing the knee into an unnatural alignment in MA-TKA [4]. The Coronal Plane Alignment of the Knee (CPAK) classification has been proposed to describe knee phenotypes using the arithmetic hip–knee–ankle angle (aHKA) and joint line obliquity (JLO) [5]. This study aimed to investigate the impact of pre- to postoperative changes in CPAK, aHKA, and JLO on patient-reported outcomes up to three years after MA-TKA.

METHODS: Between December 2019 and June 2022, we included patients who underwent primary TKA at our institution. All procedures were performed with MA-TKA using a portable navigation system (KneeAlign 2; OrthAlign, Aliso Viejo, CA, USA), and cemented posterior-stabilized (PS) Persona Knee System (Zimmer Biomet, Warsaw, IN, USA) were used. Pre- and postoperative long-leg radiographs were obtained to measure the lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA). The aHKA was defined as MPTA − LDFA, and the JLO as MPTA + LDFA. The aHKA was categorized into three groups: varus (< −2°), neutral (−2° to 2°), and valgus (> 2°). The JLO was also divided into three groups: apex distal (< 177°), neutral (177°–183°), and apex proximal (> 183°). Patients were classified according to the CPAK classification. The Knee injury and Osteoarthritis Outcome Score (KOOS) was evaluated preoperatively and at 6 months, 1 year, and 3 years postoperatively. Based on pre- and postoperative CPAK classifications, patients were divided into “unchanged” and “changed” groups. Demographic variables (age, BMI, sex) and the five KOOS subscales (Pain, Symptoms, ADL, Sports/Recreation, and QOL) were compared between the groups at all time points. In addition, subgroup analyses compared KOOS outcomes between the “unchanged” and “changed” groups for both aHKA and JLO. Statistical analyses were performed using the Mann–Whitney U test and chi-square test, with $p < 0.05$ considered statistically significant.

RESULTS: A total of 76 knees (18 male, 58 female) were included in this study. The mean age was 74.1 ± 6.7 years, and the mean BMI was 27.1 ± 4.8. The most common preoperative CPAK type was I (57%), while type V (55%) predominated postoperatively (Figure 1). 12 knees remained unchanged in CPAK, while 64 changed; there were no significant differences between the groups in demographics or preoperative KOOS. At 6 months, 1 year, and 3 years, KOOS did not differ significantly between the unchanged and changed groups for CPAK (Table 1). Regarding aHKA, there were 34 knees in the unchanged group and 42 in the changed group. No significant differences in KOOS were observed between the two groups at 6 months, 1 year, or 3 years postoperatively (Table 2). Regarding JLO, there were 26 knees in the unchanged group and 50 in the changed group. At 6 months postoperatively, the unchanged group showed significantly higher scores for Pain and ADL (Pain: $p < 0.01$; ADL: $p = 0.04$); however, neither outcome showed a significant difference at 1 year, and no significant differences remained at 3 years. (Table 2).

DISCUSSION: In MA-TKA, preservation of preoperative JLO was associated with superior Pain and ADL scores at 6 months, but this advantage diminished over time, with no differences observed at 3 years. Maintenance of native alignment may contribute to short-term functional recovery, but mid-term outcomes appear unaffected. Further studies with longer follow-up and comparisons with alternative alignment strategies are warranted.

SIGNIFICANCE/CLINICAL RELEVANCE: These findings suggest that, while restoration to a neutral mechanical axis has traditionally been emphasized, the importance of preserving individual knee phenotypes such as JLO should not be overlooked. In the mid-term, clinical outcomes may not differ according to alignment correction, indicating that attention should be paid not only to the target alignment in TKA but also to soft tissue balance.

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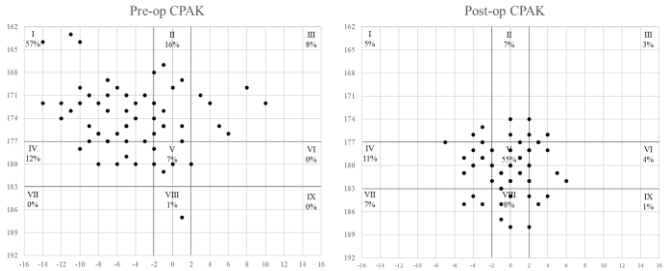

Figure 1. Pre- and postoperative CPAK classification

	Unchanged CPAK (n=12)	Changed CPAK (n=64)	P value
KOOS symptoms 6 months	81.5 ± 19.7	75.7 ± 13.6	0.19
KOOS symptoms 1 year	87.8 ± 14.1	82.6 ± 14.8	0.13
KOOS symptoms 3 year	78.9 ± 16.2	82.9 ± 12.8	0.22
KOOS pain 6 months	81.0 ± 17.4	75.9 ± 15.8	0.19
KOOS pain 1 year	86.6 ± 16.2	85.1 ± 13.1	0.39
KOOS pain 3 year	81.3 ± 20.3	84.3 ± 15.9	0.32
KOOS ADL 6 months	79.0 ± 21.8	75.0 ± 17.1	0.62
KOOS ADL 1 year	83.5 ± 18.4	80.1 ± 16.4	0.29
KOOS ADL 3 year	76.6 ± 19.7	80.7 ± 15.6	0.27
KOOS sport/Rec 6 months	36.7 ± 31.2	34.2 ± 24.7	0.25
KOOS sport/Rec 1 year	57.9 ± 34.7	42.1 ± 34.0	0.09
KOOS sport/Rec 3 year	52.0 ± 31.5	48.5 ± 27.8	0.37
KOOS QOL 6 months	56.3 ± 29.1	51.6 ± 21.5	0.31
KOOS QOL 1 year	64.6 ± 28.1	63.2 ± 24.9	0.44
KOOS QOL 3 year	58.9 ± 27.2	64.6 ± 23.8	0.26

Table 1. Comparison of KOOS at 6 months, 1 year, and 3 years postoperatively between unchanged and changed groups for CPAK.

	Unchanged aHKA (n=34)	Changed aHKA (n=42)	P value
KOOS symptoms 6 months	78.5 ± 16.0	75.4 ± 14.0	0.21
KOOS symptoms 1 year	84.6 ± 15.6	82.6 ± 14.1	0.29
KOOS symptoms 3 year	82.9 ± 14.0	81.7 ± 13.2	0.35
KOOS pain 6 months	78.3 ± 15.6	75.6 ± 16.6	0.25
KOOS pain 1 year	83.7 ± 15.3	86.7 ± 12.0	0.19
KOOS pain 3 year	84.5 ± 17.7	83.2 ± 15.9	0.37
KOOS ADL 6 months	74.5 ± 21.0	76.7 ± 15.4	0.32
KOOS ADL 1 year	80.2 ± 17.9	80.1 ± 15.9	0.43
KOOS ADL 3 year	78.1 ± 15.7	81.5 ± 16.8	0.20
KOOS sport/Rec 6 months	39.0 ± 28.3	31.1 ± 23.4	0.11
KOOS sport/Rec 1 year	48.4 ± 34.9	42.0 ± 34.2	0.22
KOOS sport/Rec 3 year	52.2 ± 27.6	46.6 ± 28.9	0.21
KOOS QOL 6 months	56.3 ± 23.9	49.4 ± 21.9	0.11
KOOS QOL 1 year	63.1 ± 25.4	63.8 ± 25.5	0.46
KOOS QOL 3 year	64.1 ± 26.0	63.3 ± 23.3	0.45

	Unchanged JLO (n=26)	Changed JLO (n=50)	P value
KOOS symptoms 6 months	78.0 ± 17.5	76.2 ± 13.5	0.34
KOOS symptoms 1 year	81.8 ± 20.0	83.0 ± 13.9	0.41
KOOS symptoms 3 year	77.6 ± 14.6	84.4 ± 12.4	0.03
KOOS pain 6 months	82.7 ± 14.7	74.0 ± 16.1	<0.01
KOOS pain 1 year	83.6 ± 19.7	84.8 ± 13.1	0.40
KOOS pain 3 year	81.5 ± 18.2	84.8 ± 15.9	0.23
KOOS ADL 6 months	80.7 ± 17.5	73.3 ± 17.9	0.04
KOOS ADL 1 year	77.6 ± 21.5	80.8 ± 15.7	0.27
KOOS ADL 3 year	77.4 ± 19.8	81.3 ± 14.4	0.21
KOOS sport/Rec 6 months	33.0 ± 26.7	35.3 ± 25.5	0.37
KOOS sport/Rec 1 year	47.8 ± 37.5	42.7 ± 33.1	0.29
KOOS sport/Rec 3 year	44.5 ± 32.6	51.3 ± 26.0	0.20
KOOS QOL 6 months	55.2 ± 27.1	51.0 ± 20.6	0.27
KOOS QOL 1 year	57.9 ± 31.8	65.2 ± 22.9	0.17
KOOS QOL 3 year	60.3 ± 30.1	65.2 ± 21.1	0.25

Table 2. Comparison of KOOS at 6 months, 1 year, and 3 years postoperatively between unchanged and changed groups for aHKA and JLO