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KNEE ARTHROPLASTY

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Ankles intermalleolar distance influences knee and ankle joint line obliquity independent of arthrosis presence or severity

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Abstract

Purpose: Lower extremity coronal alignment parameters include varus, neutral, and valgus alignment as well as knee and ankle joint line obliquity (KJLO and AJLO). KJLO and AJLO are influenced by the intermalleolar distance during long-leg standing radiographs (LSRs). This study quantifies the impact of intermalleolar distance on KJLO and AJLO during LSRs and evaluates whether it varies with osteoarthritis severity.

Methods: Radiologic analysis was conducted on 134 extremities. LSRs were obtained with the malleoli in contact and the feet placed shoulder-width apart. Two blinded observers assessed the KJLO, AJLO and other lower extremity alignment parameters in two LSRs positions (open and closed). The coronal plane alignment of the knee (CPAK) and Hirschmann classifications were determined. Patients were categorised into three groups based on osteoarthritis severity: nonarthritic, early-stage osteoarthritis, and advanced-stage osteoarthritis. Differences between the osteoarthritis severity groups were analysed using analysis of variance. Based on the power analysis, the minimum required sample size was determined to be 42 extremities per group.

Results: The mean delta intermalleolar distance between the closed and open was 13.6 ± 4.8 cm with no significant difference across the osteoarthritis severity groups. Both KJLO and AJLO differed significantly different between the open and closed images ($p < 0.001$), with the medial apex shifting proximally in the closed position ($p < 0.001$). Linear regression showed that each 1 cm reduction in the intermalleolar distance resulted in 0.39° deviation in the KJLO ($p < 0.001$), and 0.35° deviation in the AJLO ($p = 0.01$). No significant differences in delta values were observed across osteoarthritis groups ($p > 0.05$ for all). CPAK and Hirschmann classifications exhibited major subtype shifts in 6% and 25% of cases, respectively, but these differences were not statistically significant (CPAK: $p = 0.69$, Hirschmann: $p = 0.070$).

Abbreviations: aHKA, arithmetic hip knee ankle; CPAK, coronal plane alignment of the knee; DTGSA, distal tibial ground surface angle; HKA, hip knee ankle; HTO, high tibial osteotomy; ICC, intraclass correlation coefficient; JLCA, joint line convergence angle; JLO, joint line obliquity; JLOAF, joint line orientation angle by femoral condyles; JLOAM, joint line orientation angle by the middle knee joint space; JLOAT, joint line orientation angle by tibial plateau; KJLO, knee joint line obliquity; K-L, Kellgren–Lawrence; LSR's, long leg Standing Radiographs; MD, malleolar distance; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; OWHTO, open-wedge High tibial osteotomy; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty; WBLR, weight-bearing line ratio.

Conclusion: Knee and ankle joint obliquity are influenced by intermalleolar distance, independent of osteoarthritis severity. In LSRs imaging, standardising intermalleolar distance is crucial. Clinicians should account for deviations of 0.39° in KJLO and 0.35° in AJLO per centimetre of malleolar distance difference to ensure accurate measurements.

Level of Evidence: Level II, prospective cohort study.

KEYWORDS

ankle joint line obliquity, CPAK classification, Hirschmann classification, knee joint line obliquity, long-leg standing radiographs

INTRODUCTION

Accurate assessment of lower limb alignment parameters is essential in orthopaedic practice [17, 22]. Long-leg standing radiographs (LSRs) are widely used in preoperative planning and postoperative evaluation [12, 21, 24], particularly in knee osteoarthritis management [21, 24]. The key parameters assessed on LSRs include hip-knee-ankle angle (HKA), medial proximal tibial angle (MPTA), mechanical lateral distal femoral angle (mLDFA) and knee and ankle joint line obliquity measurements (KJLO, AJLO) [23]. While guidelines recommend leveling the pelvis and ensuring patellar alignment, foot positioning remains inconsistent, there is ongoing debate regarding the appropriate horizontal distance between both ankle joints [10].

Maintaining KJLO parallel to the ground is vital for clinical outcomes [22, 26]. Deviations of 4°–5° of joint obliquity is known to correlate with poor clinical outcomes [8, 19, 26]. Prior studies suggest that foot position influences KJLO and AJLO by 2–3°s, though these studies focused on patients with similar arthrosis severity [9, 12, 29]. Lee K et al. reported that in patients with advanced osteoarthritis undergoing total knee arthroplasty (TKA), every 10 cm change in intermalleolus distance resulted in a 3.7° difference in KJLO [12, 29]. However, existing studies primarily included patients with advanced osteoarthritis, leaving it unclear whether malleolus distance similarly affects knee and ankle joint inclination across different arthrosis stages. Two classification systems incorporate knee joint line obliquity into coronal alignment analysis. The coronal plane alignment of the knee (CPAK) classification considers LDFA and MPTA [16] while the Hirschmann classification integrates tibial and femoral mechanical angles with HKA [6]. Both classifications rely on LSRs for lower limb phenotyping.

This study aims to quantitatively assess the impact of intermalleolar distance on knee and ankle joint line obliquity and to determine whether this effect varies with osteoarthritis severity. A secondary objective is to evaluate whether intermalleolar distance influences the CPAK and Hirschmann classifications. The primary hypothesis was that knee and ankle joint line obliquity is affected by intermalleolar distance, with variations across osteoarthritis stages. This study is vital to improving the validity of KJLO and AJLO measurements in clinical practice and the reliability of foot position in lower limb alignment classifications.

MATERIALS AND METHODS

Patient selection study design

Patients electively admitted to a single orthopaedic clinic between 15 July and 1 November 2024, were included. Inclusion criteria: (1) Age ≥18 years, (2) closed epiphyses, (3) unrestricted hip motion, (4) no prior bony surgery or ligament pathology in the hip, knee, or ankle. Exclusion criteria: (1) History of lower extremity fracture or osteotomy, (2) knee or hip arthroplasty, (3) ligament reconstruction in the knee or ankle. A total of 134 extremities from 67 patients were analysed and classified into three groups by two orthopaedic specialists: nonarthritic (Group 1: 44 extremities), early-stage osteoarthritis (Kellgren–Lawrence [K–L] 1–2; Group 2: 44 extremities), and advanced-stage osteoarthritis (K–L 3–4; Group 3: 46 extremities). Two patients had knees classified into different groups for each limb. All participants provided informed consent.

Radiographic imaging and measurement protocol

LSRs were acquired in two standardised positions using Fujifilm FDR Smart X-ray Equipment. Bilateral LSRs were obtained with patients standing, first with feet in a closed position (malleoli in contact as much as possible) and then shoulder-width apart. In both positions, the patella faced forward, the knees were in full extension, and the feet were aligned forward. All LSRs were performed by a single experienced radiology technician, accompanied by one of the orthopaedic surgeons (Observer 1 or 2), who ensured image suitability. Nonvisible hip, knee, or ankle joints were identified and repeated as needed. A minimum 5 cm difference in malleolar distance was required between open and closed positions.

Radiographs were transferred to the hospital's picture archiving and communication system (PACS) for analysis. Distance and angle measurements (minimum 1° angular and 0.1 mm linear resolution) were performed by two blinded orthopaedic surgeons (Observers 1 and 2). Prior to measurements, a consensus meeting was held to standardise the methodology. The following lower limb alignment parameters were measured: malleolar distance (MD), HKA [14], weight bearing line ratio (WBLR) [7], MPTA [20], mLDFA [20], KJLO [23], joint line convergence angle (JLCA) [15] and distal tibial ground surface angle (DTGSA) [23] (Figure 1). CPAK classification was derived from MPTA and mLDFA to construct a 9-mesh CPAK diagram incorporating JLO and arithmetic HKA. Hirschmann classification was created using HKA, tibial mechanical angle (TMA) and femoral mechanical angle, where MPTA and 180°—mLDFA were utilised, respectively.

Measurements were performed separately for closed and open LSRs. Delta values were calculated as open

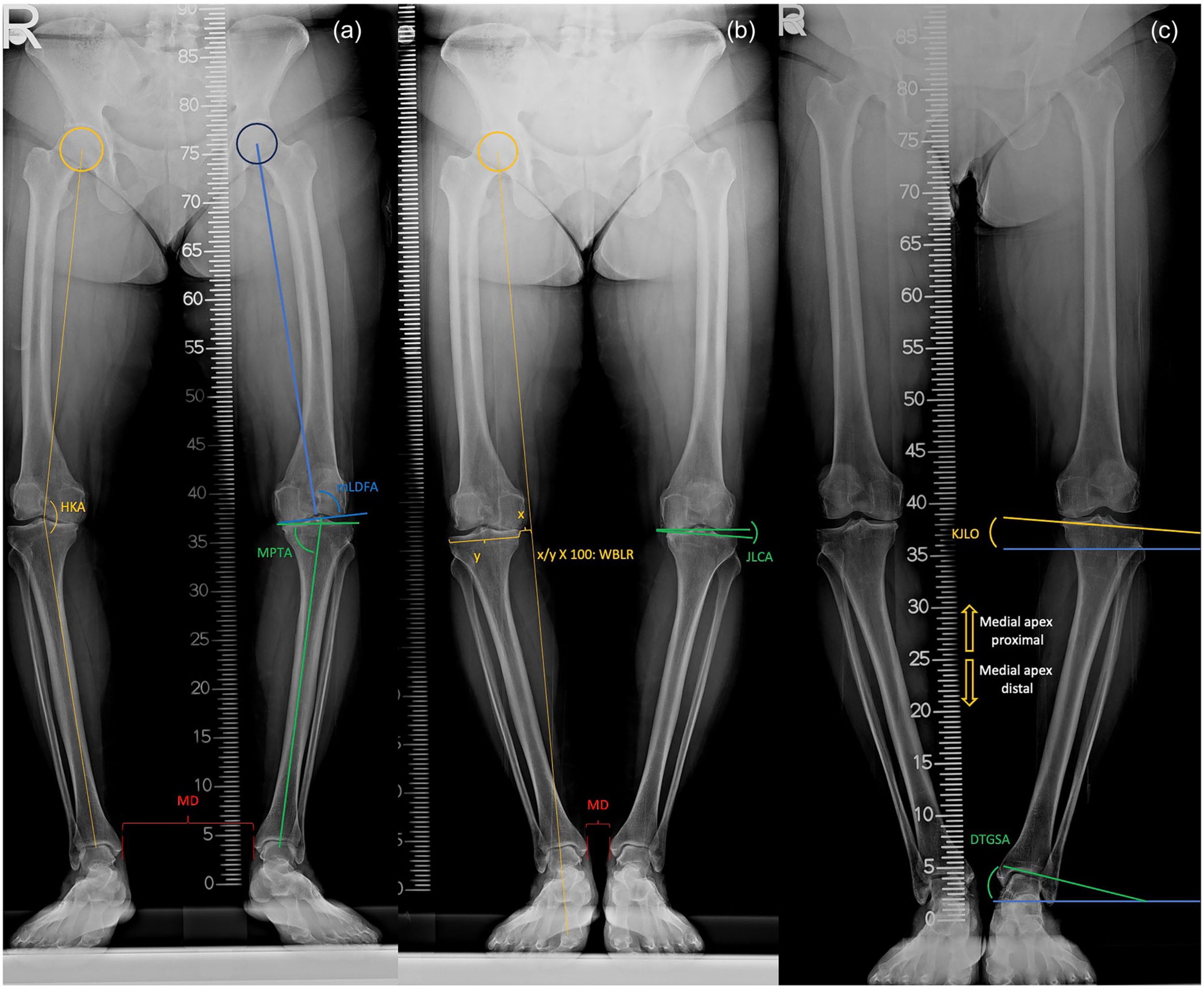

FIGURE 1 Measurements in long-LSRs. (a) The measurement of malleolar distance refers to the distance between lines drawn perpendicular to the ground and tangent to both malleoli. (b) WBLR was recorded as positive (+%) when the WBL passed through the joint and as negative (-%) when it passed medial to the joint. (c) KJLO refers to the angle formed between the line tangent to the proximal tibial articular surface (yellow line) and the ground (blue line), while DTGSA refers to the angle formed between the line tangent to the distal tibial articular surface (green line) and the ground (blue line). DTGSA, distal tibial ground surface angle; HKA, hip knee ankle; JLCA, joint line convergence angle; KJLO, knee joint line obliquity; LSRs, leg standing radiographs; MD, malleolar distance; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; WBL, weight-bearing line; WBLR, weight-bearing line ratio.

LSRs value—the closed LSRs value for continuous measurements (MD, HKA, WBLR, MPTA, mLDFA, KJLO, JLCA and DTGSA). For categorical parameters (CPAK classification and Hirschmann classification), subtype variations between open and closed LSRs were assessed as per the following: in CPAK classification, identical subtypes were considered similar; a one-unit change (e.g., Type 1 → Type 2) was classified as a minor change, while a two-unit or greater change (e.g., Type 1 → Type 4) was considered a major change. Whereas, in Hirschmann classification, identical subtypes (NEUHKA0° + NEUFMA0° + NEUTMA0°) were considered similar. A single-unit change in FMA or TMA was minor, while any HKA change (e.g., NEUHKA → VARHKA3) was classified as a major change.

In value assignments, HKA, MPTA and mLDFA, were analysed using actual values. KJLO, JLCA and DTGSA, were assigned using negative values for medial angulation and positive values for lateral angulation. WBLR was recorded as positive (+%) when the weight-bearing line (WBL) passed through the joint and as negative (−%) when it passed medial to the joint. KJLO and DTSGA were considered gold standard measurements for knee and ankle joint line obliquity, respectively. Correlations between body mass index (BMI), age and sex with radiological parameters in open and closed LSRs were analysed.

Each measurement (MD, HKA, WBLR, MPTA, mLDFA, JLCA, KJLO and DTGSA) was repeated at 4–8 weeks intervals, and the mean of four measurements (Observer 1 and 2) was used for analysis. Inter- and intraobserver reliability were calculated using the intraclass correlation coefficient (ICC) and an ICC value < 0.40 was evaluated as poor, 0.59–0.40 as fair, 0.75–0.60 as good and >0.75 as excellent agreement. Results were reported with 95% confidence intervals ($p < 0.05$) (Table 1).

To determine the appropriate sample size, a pilot study was conducted using KJLO values, the main outcome, measured in open and closed LSRs to determine the appropriate sample size. The mean KJLO was 3.9° ± 1.2° in the open position and −4.7° ± 1.4° in the closed position, with a correlation coefficient of −0.538 between the two measurements. Based on these values, a sample size analysis was performed using G*Power version 3.1. A two-tailed paired-samples *t*-test was selected, with a significance level of 0.05 and a power of 0.95. To allow for a potential 10% data loss, we increased the group size to include at least 42 extremities per group. This prospective study was approved by Erzurum Regional Training and Research Hospital Ethics Committee (Decision No: 144, 10.07.2024) and conducted per the Helsinki Declaration.

Statistical analysis

Statistical analyses were performed using SPSS version 26.0. Categorical variables (sex, CPAK classification type and Hirschmann classification type) were reported as frequencies (%), while continuous variables (age, BMI, MD, HKA, MPTA, mLDFA, WBLR, JLCA, KJLO and DTGSA) were presented as means ± SD. Comparative analyses were conducted using chi-square or Fisher's exact test for categorical variables, Student's *t*-test for two-group comparisons; analysis of variance (ANOVA) for multiple groups, and Pearson or Spearman correlation based on normality; partial correlations adjusted for age, sex and BMI.

TABLE 1 Intra- and interobserver reliability by variable.

Variable	Intraobserver ICC 95% CI (minimum–maximum)	Comment	Interobserver ICC 95% CI (minimum–maximum)	Comment
MD (cm)	0.97 (0.93–1.00)	Excellent	0.97 (0.94-1.00)	Excellent
HKA (°)	0.96 (0.92–0.99)	Excellent	0.98 (0.96–1.00)	Excellent
WBLR (%)	0.95 (0.92–0.97)	Excellent	0.92 (0.88–0.97)	Excellent
MPTA (°)	0.89 (0.77–0.95)	Excellent	0.87 (0.77–0.93)	Excellent
mLDFA (°)	0.89 (0.78–0.95)	Excellent	0.85 (0.79–0.94)	Excellent
JLCA (°)	0.79 (0.73–0.85)	Excellent	0.77 (0.71–0.84)	Excellent
KJLO (°)	0.94 (0.89–0.97)	Excellent	0.91 (0.83–0.95)	Excellent
DTGSA (°)	0.88 (0.75–0.95)	Excellent	0.89 (0.79–0.95)	Excellent

Abbreviations: CI, confidence interval; DTGSA, distal tibial ground surface angle; HKA, hip knee ankle; ICC, intraclass correlation coefficient; JLCA, joint line convergence angle; KJLO, knee joint line obliquity; MD, malleolus distance; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; WBLR, weight-bearing line ratio.

Linear regression assessed independent variable effects ($p < 0.05$ significance level).

RESULTS

The cohort included 41 females and 26 males (mean age: 48.5 ± 16.8 years, range: 18–81; mean BMI: 28.1 ± 3.8 kg/m²). In the overall study population, the delta MD was 13.6 ± 4.8 cm, with no significant difference between groups. HKA was significantly lower in the closed LSRs position ($p = 0.03$), while JLCA showed greater lateral angulation in the close LSRs position ($p = 0.012$). No significant differences were observed for WBLR, MPTA, or mLDFA between open and closed LSRs positions (Table 2). The mean MPTA was 86.3 ± 2.5° (open) and 86.1 ± 2.3° (closed) while, the mean mLDFA was 89.8 ± 3.0° (open) and 89.6 ± 2.6° (closed). Delta values for all measurement parameters did not differ significantly between groups ($p > 0.05$ for all) (Table 3).

The KJLO and DTGSA significantly differed between the open and closed LSRs position ($p < 0.001$) with the closed positions showing greater proximal angulation. Linear regression showed that each 1 cm increase in MD 0.39° proximal shift in KJLO ($p < 0.001$), and a 0.35° proximal shift in DTGSA ($p = 0.019$).

BMI differed significantly between osteoarthritis groups (Group 1: 26.4 ± 4.8 kg/m², Group 2: 28.5 ± 2.5 kg/m², Group 3: 29.3 ± 3.3 kg/m²; $p = 0.003$). However, delta KJLO and delta DTGSA showed no correlation with BMI, age, or sex (all $p > 0.05$) even after adjusting for age and sex (delta KJLO: Rho = 0.034, $p = 0.70$; delta DTGSA: Rho = −0.88, $p = 0.32$).

When comparing open and closed LSRs, the CPAK and Hirschmann classifications showed similarity rates of 64.2% and 28.4%, respectively, with no significant differences between arthritis severity groups (CPAK: $p = 0.80$, Hirschmann: $p = 0.50$). Major classification changes occurred in 6.0% (CPAK) and 25.4% (Hirschmann), while minor classification changes were observed in 29.8% (CPAK) and 46.2% (Hirschmann), with no statistically significant differences among groups (CPAK: $p = 0.72$, Hirschmann: $p = 0.076$).

DISCUSSION

The most important finding from the study is confirmation of the first part of the hypothesis, that MD significantly affects knee and ankle joint line obliquity, with the apex shifting proximally as MD decreases (1 cm =

TABLE 3 Comparison of measurement parameters of nonarthrosis, early-stage osteoarthritis and advanced-stage osteoarthritis groups in terms of delta values.

Delta values	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD	*p*-Value
MD (cm)	14.5 ± 5.2	13.5 ± 4.8	13 ± 4.3	0.26
HKA (°)	0.2 ± 1.6	0.5 ± 1.4	0.4 ± 2.1	0.42
WBLR (%)	−0.2 ± 5.8	0.9 ± 4.1	−0.8 ± 8.6	0.18
MPTA (°)	−0.1 ± 1.3	0.2 ± 1.7	0.3 ± 1.1	0.18
mLDFA (°)	−0.1 ± 2	0.2 ± 1.4	0.3 ± 1.8	0.35
JLCA (°)	0.4 ± 1.3	0.1 ± 1.1	0.3 ± 1.6	0.54
KJLO (°)	−5 ± 2.8	−4.5 ± 2.6	−4 ± 2.6	0.18
DTGSA (°)	−4.6 ± 3.1	−4.2 ± 2.7	−3.9 ± 2.6	0.60

Abbreviations: DTGSA, distal tibial ground surface angle; HKA, hip knee ankle; JLCA, joint line convergence angle; KJLO, knee joint line obliquity; LSR, long-leg standing radiographs; MD, malleolus distance; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; SD, standard deviation; WBLR, weight-bearing line ratio.

TABLE 2 Comparison of open and closed LSRs for all study population.

	Open LSRs Mean ± SD	Close LSRs Mean ± SD (range)	Delta Mean ± SD (range)	*p*-Value
MD (cm)	16.1 ± 5	2.4 ± 1.2	13.6 ± 4.8	**<0.001**
HKA (°)	174.4 ± 4.4	174. 03 ± 4.3	0.4 ± 1.7	**0.017**
WBLR (%)	28.5 ± 20.02	28.5 ± 19.8	−0.03 ± 6.5	0.55
MPTA (°)	86.3 ± 2.5	86.1 ± 2.3	0.15 ± 1.4	0.20
mLDFA (°)	89.8 ± 3	89.6 ± 2.6	0.2 ± 1.7	0.25
JLCA (°)	−1.5 ± 2.3	−1.8 ± 2.5	0.3 ± 1.3	**0.012**
KJLO (°)	−1.8 ± 3.	2.7 ± 2.3	−4.5 ± 2.7	**<0.001**
DTGSA (°)	−2.5 ± 5.6	1.7 ± 5.2	−4.3 ± 2.8	**<0.001**

Note: Bold values indicate statistically significant.

Abbreviations: DTGSA, distal tibial ground surface angle; HKA, hip knee ankle; JLCA, joint line convergence angle; KJLO, knee joint line obliquity; LSR, long-leg standing radiographs; MD, malleolus distance; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; SD, standard deviation; WBLR, weight-bearing line ratio.

0.39° for KJLO, 1 cm = 0.35° for DTGSA). However, MD's impact on KJLO, HKA and DTGSA was not consistent across arthrosis severity groups. The clinical relevance of these findings indicates that failure to apply delta correction may lead to inaccurate obliquity measurements, necessitating a 1 cm correction per MD variation in repetitive LSRs. MPTA and mLDFA, reflecting bone anatomy, remain unaffected by MD. However, despite being based on these parameters, CPAK classification was influenced by MD, suggesting even minor MPTA and mLDFA changes can alter CPAK classification, underscoring the need for precision in clinical and research applications.

Xie et al. proposed three methods for assessing KJLO: joint line orientation angle by femoral condyles (JLOAF), by the middle knee joint space (JLOAM), and by the tibial plateau (JLOAT) [29]. Xie et al. found that all methods were influenced by stance width and weight-bearing conditions in early-stage osteoarthritis patients undergoing OWHTO. The presented study evaluated the JLOAT-equivalent KJLO method across varying arthrosis severities, finding no significant difference in KJLO changes. Unlike Xie et al., it was observed in the presented study, that delta KJLO and delta AJLO were unaffected by BMI. Whereas, consistent with Xie et al. findings, MPTA remained stable regardless of malleolar distance, reinforcing its nature as a bone-based parameter.

Clinically, post-OWHTO, MPTA > 95° predicts poor outcomes, while KJLO > 4° correlates with lower clinical scores, and >6° increases lateral compartment degeneration risk [8, 26]. Although Xie et al. favoured MPTA as the most reliable knee joint obliquity measure, it does not directly correlate with KJLO changes. MPTA affects both the knee and ankle, with a 9° MPTA change corresponding to a 4.1° KJLO correction [12]. While the closed LSRs technique standardises measurements, it does not replicate natural gait. MD correction is strongly recommended as it is essential for accurate KJLO assessment, which is crucial for predicting OWHTO outcomes.

The parallel alignment of the knee joint line to the ground is important not only in patients undergoing osteotomy but also in those undergoing TKA [25]. Lee et al. reported that in patients undergoing TKA, knee joint obliquity changes by 3.7° per 100 mm [13]. However, Lee et al.'s study, based on implant measurements, differs from the presented study, which assessed native knees across varied age groups and ligament flexibility. Nevertheless, the findings from the presented study, align with Lee et al.'s correction rate (3.7° per 100 mm) while also quantifying ankle joint obliquity (0.35° per 10 mm). Additionally, while Lee et al. used intertalar distance, intermalleolar distance was measured in the presented study, which may offer a more practical clinical parameter.

Following medial opening high tibial osteotomy and low tibial osteotomy, the lower limb alignment tends to shift towards valgus alignment [28]. The ESSKA Consensus Study Group on osteotomy around the painful degenerative varus knee emphasised the critical role of the load-bearing line in surgical planning [3]. This study showed that WBLR is not affected by the distance between the malleoli. While WBLR can be measured without considering the malleolar distance, HKA is influenced by it, with varus increasing as the malleolar distance decreases. However, the clinical importance of this statistically significant change is unclear. Another finding of our study is that JLCA is influenced by malleolar distance, additionally it has been frequently reported in the literature to be affected by the level of osteoarthritis [15, 29].

Although it has long been recognised that the terms varus, neutral and valgus alone may not be sufficient in coronal alignment and that knee joint line obliquity may influence clinical outcomes, Hirschmann et al. introduced a novel classification in 2019 that accounts for both joint line obliquity and coronal alignment, incorporating 125 potential subtypes [6]. Two years later, MacDessi et al. proposed another classification that also considers coronal alignment and knee joint line obliquity [16]. These two classifications, whose clinical significance is increasingly being elucidated, demonstrate high intra- and interobserver reliability [11, 23]. The patient-specific alignment (PSA) technique aims to achieve more physiological prosthetic positioning by restoring native bony phenotypes and joint line obliquity. Accurate lower limb alignment assessment is essential for implementing PSA, and our findings may help refine measurement techniques in this context. Although the significance and contribution of these two classifications in knee osteotomies and unicompartmental knee arthroplasty remain unclear, they serve as valuable guides for alignment targets in TKA [1, 2, 5, 11, 24].

In the presented study, it was observed that both classifications were influenced by open and closed LSRs positions. The rate of major change was 6% for the CPAK classification and 25% for the Hirschmann classification. In clinical practice, the malleolar distance is unlikely to differ by 13 cm during preoperative and postoperative LSRs. However, clinicians should be aware that these two classifications may be influenced by malleolar distance. Moreover, according to the presented data, HKA varied between open and closed LSRs measurements, which is likely the primary reason for the high rate of change observed in the Hirschmann classification. This finding is expected, as the CPAK classification is based on a threshold of 4° aHKA and 6° JLO, whereas the Hirschmann classification incorporates three variables (HKA, FMA and TMA), each with a 3° cut-off, making it inherently more sensitive to minor alignment variations. Additionally, the Hirschmann classification is an HKA-based system that provides insight into both bone and soft tissue balance, whereas the CPAK classification does not account for soft tissue balance [11].

The are several limitations of the presented study. First, rotation may influence measurement accuracy. Despite the presence of observers in the radiology room, minor rotational errors could have occurred. Maderbacher et al. reported that standardised measurements might exhibit deviations of 0.4°–1.7° in MPTA and mLDFA due to rotational variations [18]. Second, tomography-based studies offer higher measurement standards. Tarassoli et al. analysed CT scans in patients undergoing robotic-assisted TKA and found that LSRs influenced CPAK classification, with CT imaging more frequently identifying structural varus and an apex distal position (CPAK Type 1) [27]. However, CT scans are rarely performed in routine practice for osteotomy planning or nonrobotic-assisted knee arthroplasties due to increased radiation exposure. Fontalis et al. demonstrated a strong correlation between CT and LSRs in primary robotic-arm-assisted TKA, but this correlation weakened in cases with rotational deformities or JLCA deviations exceeding ±5 [4]. It is evident that rotation reduces measurement consistency. Although there was no rotational analysis in the presented study, it was ensured that evaluations were conducted on images where the patella was centred between the femoral condyles. Another potential factor contributing to these variations is tibial slope, yet no data in the literature specifically address its effect on MPTA or JLCA. Finally, in the clinical scenario, the malleolar distance is unlikely to differ by 13 cm during repeated LSRs.

CONCLUSION

Knee and ankle joint obliquity are influenced by intermalleolar distance, independent of osteoarthritis severity. In LSRs imaging, standardising intermalleolar distance is crucial. Clinicians should account for deviations of 0.39° in KJLO and 0.35° in AJLO per centimetre of malleolar distance difference to ensure accurate measurements.

AUTHOR CONTRIBUTIONS

All authors contributed to the study design, data collection, data analysis, and reporting for this manuscript. All authors have read and approved the final submitted manuscript.

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The authors have nothing to report.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available on reasonable request from the corresponding author.

ETHICS STATEMENT

Ethics committee approval was obtained from Erzurum Regional Training and Research Hospital (Decision No: 144, 10.07.2024). Consent to participate was obtained from all patients to use their radiographs for this research in accordance with the principles of the Helsinki declaration.

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