The Egyptian Orthopedic Journal

Vol. 60, No. 1, 2025
ISSN: 1110-1148 (print)
ISSN: 2090-9926 (online)
DOI: 10.21608/EOJ.2025.419273

ORIGINAL ARTICLE

Distribution of Coronal Plane Alignment of the Knee Classification in Patients with Knee Osteoarthritis in Malaysia

Sarbhjit S. L. Singh[a], Teh H. Lian[b], Jade H. P. Yuik[a], Sarbhan S. L. Singh[c], Ahmad F. Bin Mohamed[d], Kunalan Ganthel[a]

Department of [a]Orthopaedic Surgery, [d]Radiology, Hospital Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia; [b]Department of Orthopaedic Surgery, Hospital Raja Permaisuri Bainun, Ipoh, Perak; [c]Institute for Medical Research, National Institutes of Health Malaysia, Ministry of Health Malaysia, Setia Alam, Selangor, Malaysia.

Correspondence to *Sarbhjit S. L. Singh, Department of Orthopaedic Surgery, Hospital Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia.*
E-mail: sarb_14@yahoo.com

Objectives Research suggests differences in coronal plane alignment of the knee (CPAK) classification between Asian and Western populations. This study aimed to determine the CPAK classification and to compare the sex and ethnic differences in arthritic knees in the Malaysian population.

Subjects and Methods This retrospective cohort study included 250 arthritic patients (500 knees) scheduled for total knee arthroplasty and unicondylar knee arthroplasty between 2023 and 2024 at a tertiary hospital in Malaysia. The lateral distal femoral angle and medial proximal tibial angle were measured using digital long leg radiographs. A complete and independent set of measurements were performed by a radiologist to validate the collected data.

Results In this study, the most common type of CPAK classification was Type I (45.2%), followed by types IV (22.4%) and V (9.6%) in the arthritic Malaysian population. CPAK type VIII was the rarest type, accounting for only 0.8% of cases. The most common CPAK classification among both sexes (male and female) and among the three ethnic groups of the Malaysian population (Malay, Chinese, and Indian) was also similar, with Type I being the most common, followed by Type IV and Type V.

Conclusion Constitutional varus is more common in the Malaysian population than in their Western counterparts. Most Malaysian populations with arthritis are better suited to Kinematic Alignment total knee arthroplasty. Surgical outcomes can be optimized by understanding the typical CPAK distribution by tailoring surgical approaches such as alignment principles and ligament balancing techniques to better suit the inherent knee anatomy of Malaysian patients.

Keywords Coronal plane alignment of the knee classification, Ethnic, gender, Malaysia, Total knee arthroplasty.

INTRODUCTION

The background of coronal plane alignment of the knee

The CPAK classification represents Coronal Plane Alignment of the Knee classification. The CPAK classification categorizes knee alignment based on two key features: the arithmetic hip-knee angle (aHKA) and Joint Line Obliquity (JLO). HKA reflects the inherent alignment of the leg and is categorized as varus (bowed inward), neutral, or valgus (bowed outward). JLO indicates how slanted the joint surface of the knee is classified as having an apex distal (tilted downward), neutral, or proximal (tilted upward) [1]. The CPAK system combines these two factors to create nine distinct knee phenotypes [2]. This classification helps understand the different knee joint configurations in healthy and arthritic knees. In addition, it will ensure consistent reporting in future knee alignment studies. MacDessi *et al*., did a radiological analysis of

500 healthy and 500 osteoarthritic knees to assess the applicability of the CPAK classification [2]. The most common types were Type II, followed by Type 1 and Type V. CPAK helps to identify the knee that is best suited for a certain alignment. For example, anatomic alignment total knee arthroplasty (TKA) should be considered for CPAK Type II, mechanical alignment TKA should be considered for CPAK Type V, and kinematic alignment (KA) TKA should be considered for CPAK Types I, III, IV, and VI.

CPAK differences across various populations

Many studies have revealed differences between Asian and Western populations in terms of anatomical dimensions [3–6]. Research suggests differences in the CPAK classification between Asian and Western populations. These include a lower HKA. Asians tend to have straighter legs (valgus) than a slight inward angulation (varus), which is more common in Caucasians. Femoral bowing is also higher in Asians than that in Caucasians. Owing to these anatomical variations, the distribution of CPAK categories may differ between Asian and Western populations. Asians may have a higher prevalence of certain CPAK classifications, such as neutral or valgus alignment, than Western populations. Hsu *et al*., conducted radiological analysis of 214 healthy knees in 214 Asian individuals to validate and modify the CPAK classification in the Asian population [4]. They identified a very high percentage of knees with apex distal JLO when the CPAK classification was applied to the Asian population. The most common types were types II and V, followed by type I, based on the modified CPAK classification. Samant *et al*., did a radiological analysis of 200 healthy knees and 250 osteoarthritic knees to determine the CPAK classification in the Indian population [7]. They concluded that constitutional varus is more common in the Indian population than in their Western counterparts. Arthritic Indian knees were predominantly classified as CPAK types I and VI.

Significance of determining CPAK classification among the Malaysian population

Determining the CPAK classification for the Malaysian population is important for several reasons. First, anatomical variations can be addressed. Malaysia is a multicultural country mainly comprising Malay, Chinese, and Indian ethnicities. CPAK can provide a more accurate picture of these variations in Malaysian patients undergoing knee surgery. Surgical outcomes can also be optimized by understanding the typical CPAK distribution in Malaysia, as surgeons can tailor surgical approaches (e.g. ligament balancing techniques) to better suit the inherent knee anatomy of Malaysian patients. This could potentially lead to improved surgical outcomes, faster recovery times, and improved long-term joint health. The risk of complications may also be reduced. A better understanding of CPAK might help surgeons identify patients at a higher risk of specific complications after TKA, such as patellar instability or ligament imbalance. This allows for the implementation of preventive measures during surgery or the recommendation of alternative treatment options for high-risk cases. The CPAK classification can provide patients with a clearer picture of their knee anatomy and how it compares with the general Malaysian population with regard to sex and ethnic background. This knowledge can help them to participate more actively in discussions about treatment options and expected outcomes with surgeons. It will also help guide future research by establishing a baseline for CPAK classification in Malaysia. This can pave the way for further research on knee health and diseases in the Malaysian population. These data can be valuable for developing targeted prevention strategies and treatment protocols for knee osteoarthritis or other knee conditions.

Generalizing international findings in a local context may be inaccurate because of differences in ethnic, sociodemographic, economic, and healthcare characteristics. Unfortunately, there has been no extensive research on CPAK classification, specifically in Malaysians. This study aimed to determine the CPAK classification and to compare sex and ethnic differences in arthritic knees among the Malaysian population. In addition, the current study also compared the mechanical HKA (mHKA), medial proximal tibial angle (MPTA), and lateral distal femoral angle (LDFA) angle measurements between the researcher and radiologist. This study is warranted to confirm these suppositions and to establish a more accurate picture of knee anatomy in this specific population.

SUBJECTS AND METHODS

A retrospective cohort study involving 250 consecutive patients with arthritis scheduled for TKA and unicondylar knee arthroplasty between 2023 and 2024 was conducted at a tertiary hospital. The sample size for this study was determined based on the study objectives using the largest estimated sample as the final target. Calculations were performed with Open Epi software, specifically employing the 'Sample size for frequency in a population' method. The rationale for the final sample size involved accounting for the study's population size, a confidence level of 95%, and a distribution percentage in knee types with apex distal JLO set at 89%, based on a study by Hsu *et al*., [4]. To ensure robustness and account for potential data loss or variability, the calculated sample size of 151 participants was inflated by 65%, resulting in a final target of 250 participants. The inclusion criteria were all patients aged greater than or equal to 50 years who were scheduled for TKA and unicondylar knee arthroplasty between 2023 and 2024. Patients with a history of lower limb fractures, surgical intervention of the lower limbs, and deformities of the lower limbs (congenital or acquired) were excluded. Patients with a history of secondary arthritis, such as rheumatoid arthritis, gouty arthritis, hemophilia, septic arthritis, neuromuscular disease, or spondyloarthropathy, were also excluded. Finally, those with poor quality digital long leg radiographs (LLRs) were also excluded.

We manually retrieved the following demographic data from patients' medical records: age, sex, ethnicity, weight, height, and BMI. Philips Medical Systems radiography tube housing assembly model SRO 33100 ROT 360 (manufactured October 2010, Hamburg, Germany) was used in the present study. Both lower limbs were imaged to provide data for 500 knees. The rotation profile errors of the digital LLRs were minimized using these two methods. First, the patella was used as a key landmark for the anteroposterior orientation of the lower limb. This is the most widely used technique for the long-leg radiograph protocol published by Paley and Herzenberg [8]. Subsequently, we used the protocol proposed by Nguyen *et al*., for long leg radiographs which had excellent and reproducible HKA measurements, with clinically acceptable degrees of error [9]. The patients stood with their knees fully extended. Their feet were then positioned at a distance of 10cm between the heels and aligned at 10° of external rotation from the midline by placing the feet on a standardized positioning template. The radiographic technicians subsequently adjusted the hip rotation by aligning the upper body and pelvis in a straightforward anterior-posterior position. No support was used to ensure full weight-bearing, and the patients were instructed to distribute their weight equally to each leg. Measurements were made on the LLRs using an online digital planning tool, the Bonesetter application (Figure 1). The Bonesetter app (Bonesetter Solutions LLC, Ann Arbor, Michigan, USA) was developed to aid in surgical planning of deformity, templating fracture reduction, and joint replacement [10]. The mHKA angle was defined as the angle subtended by the mechanical axes of the femur and tibia. The LDFA was defined as the lateral angle formed between the femoral mechanical axis and joint line of the distal femur [2]. The MPTA was defined as the medial angle between the tibial mechanical axis and the joint line of the proximal tibia [2]. Each parameter was measured thrice, and the mean was used as a definite measurement. From these two parameters, the aHKA angle (aHKA: MPTA – LDFA) as an indicator of varus or valgus alignment and JLO (MPTA + LDFA) as an indicator ofthe joint surface slope were calculated. Varus or valgus alignment was categorized as aHKA less than –2° for varus, –2° less than or equal to aHKA less than or equal to 2° for neutral, and aHKA greater than 2° for valgus. JLO was classified as less than 177° for apex distal, 177° less than or equal to JLO less than or equal to 183° for neutral, and greater than 183° for apex proximal. Based on these criteria, the cases were categorized into nine phenotypes [2]. The principal investigator performed all measurements.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0, International Business Machines, IBM Corp (released 2019 from Armonk, New York, USA), descriptively using percentages and frequencies for categorical variables and mean and SD for continuous variables (i.e., LDFA, MPTA, aHKA, JLO). A radiologist performed a complete and independent set of measurements to validate the collected data. The Intraclass Correlation Coefficient for Agreement (ICCA) was calculated to assess the agreement between measurements collected by the researcher and those collected by an independent radiologist. The significance level was set at p less than 0.05.

RESULTS

This study included 250 patients (500 patients with arthritic knees). The cohort comprised 66 (26.4%) males and 184 (73.6%) females. The mean age of the male patients was 68.89 years (SD±8.13), while the mean age of the female patients was 68.62 years (SD±7.94), indicating a similar age distribution between the sexes. Regarding body mass index (BMI), the mean BMI for males was 27.24 (SD±4.02) and for females, it was 29.15 (SD±4.72). These values suggest that on average, female patients had a slightly higher BMI than male patients in this study population. There were 162 arthritic knees (81 patients) in the Malay population, 172 arthritic knees (86 patients) in the Chinese population, and 166 arthritic knees (83 patients) in the Indian population.

The distribution of the CPAK classification in the study population (n=500 knees) revealed that CPAK I was the most prevalent phenotype overall, representing 45.2% (n=226) of the total sample. This was followed by CPAK IV, which accounted for 22.4% (n=112) of knees. Other notable classifications were CPAK V (9.6%, n=48), CPAK II (8.8%, n=44), and CPAK III (5.2%, n=26). The less common types were CPAK VI (4.0%, n=20), CPAK IX (2.4%, n=12), and CPAK VII (1.6%, n=8). CPAK VIII was the least common, comprising only 0.8% (n=4) of the total sample (Figure 2a and Tables 1 and 2). When considering sex, CPAK I remains the most common type among both females and males. In females, CPAK I accounted for 164 (32.8%) knees, while in males, it accounted for 62 (12.4%) knees. CPAK IV was the next most common classification for females (70 knees, 14%) and also showed a similar trend in males (42 knees, 8.4%) (Figure 2a and Table 1). Regarding ethnicity, CPAK I is the predominant classification across all groups, comprising 74 knees in the Malay population, 82 knees in the Chinese population, and 70 knees in the Indian population. CPAK IV was also consistently the second most common type, with higher representation among the Chinese (40 knees) and Indian (46 knees) populations compared with the Malay group (26 knees). Other classifications vary in prevalence among ethnicities, but CPAK II, CPAK V, and CPAK III also showed notable representation across all three groups. CPAK classifications VII, VIII, and IX were the least represented types overall, with minimal occurrence within each ethnic group (Figure 2b and Table 1).

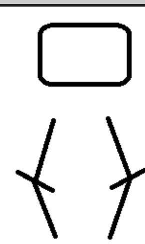
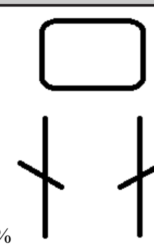
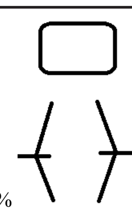
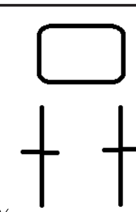
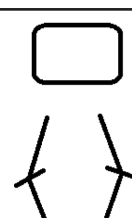
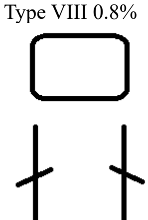
Table 3 presents the agreement between measurements made by the researcher and radiologist evaluated using the ICCA. The highest agreement was observed for the mHKA angle, with an ICCA of 0.970 (95% CI: 0.778-0.996, *p=0.001), indicating excellent agreement. The MPTA and LDFA also demonstrated moderate-to-good agreement, with ICCA values of 0.861 (95% CI: –0.041–0.981, *p=0.031) and 0.848 (95% CI: 0.133–0.978, *p=0.026), respectively. Overall, the results suggest that there is strong and significant agreement between the researcher and radiologist for the mHKA, MPTA, and LDFA angle measurements.

Table 1: Distribution for CPAK classification among both the sexes across the Malay, Chinese, and Indian population (n=500 knees)

	Females			Male			Overall (Male and Female)			
CPAK	**Malay**	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**	**Total *N* (%)**
I	50	62	52	24	20	18	74	82	70	226 (45.2)
II	16	14	10	4	0	0	20	14	10	44 (8.8)
III	8	6	8	2	2	0	10	8	8	26 (5.2)
IV	16	22	32	10	18	14	26	40	46	112 (22.4)
V	10	10	14	6	8	0	16	18	14	48 (9.6)
VI	4	0	12	2	2	0	6	2	12	20 (4.0)
VII	6	0	0	0	2	0	6	2	0	8 (1.6)
VIII	2	2	0	0	0	0	2	2	0	4 (0.8)
IX	2	4	6	0	0	0	2	4	6	12 (2.4)
Total	114	120	134	48	52	32	162	172	166	500 (100)

Note. CPAK: Coronal plane alignment of the knee.

Table 2: Percentage of patients in this study in the various CPAK classification types

Arithmetic HKA (MPTA – LDFA) Joint line Obliquity (MPTA + LDFA)	Varus (< –2°)	Neutral (–2° to +2°)	Valgus (> +2°)
Apex Distal (<177°)	 Type I 45.2%	 Type II 8.8%	 Type III 5.2%
Apex Neutral (177–183°)	 Type IV 22.4%	 Type V 9.6%	 Type VI 4%
Apex Proximal (>183°)	 Type VII 1.6%	Type VIII 0.8% 	 Type IX 2.4%

Note. CPAK: Coronal plane alignment of the knee; HKA: Hip knee angle; LDFA: Lateral distal femur angle; MPTA: Medial proximal tibial angle.

Table 3: Agreement between measurement made by researcher and the radiologist

		95% Confidence Interval		
Parameter	**ICC$_A$**	**Lower bound**	**Upper bound**	***p*-value**
mHKA	0.970	0.778	0.996	0.001*
MPTA	0.861	–0.041	0.981	0.031*
LDFA	0.848	0.133	0.978	0.026*

Note. mHKA: Mechanical hip knee angle; LDFA: Lateral distal femur angle; MPTA: Medial proximal tibial angle; ICCA: Intraclass Correlation Coefficient Agreement using two way mixed model with absolute agreement; *significance set at *p* less than 0.05.

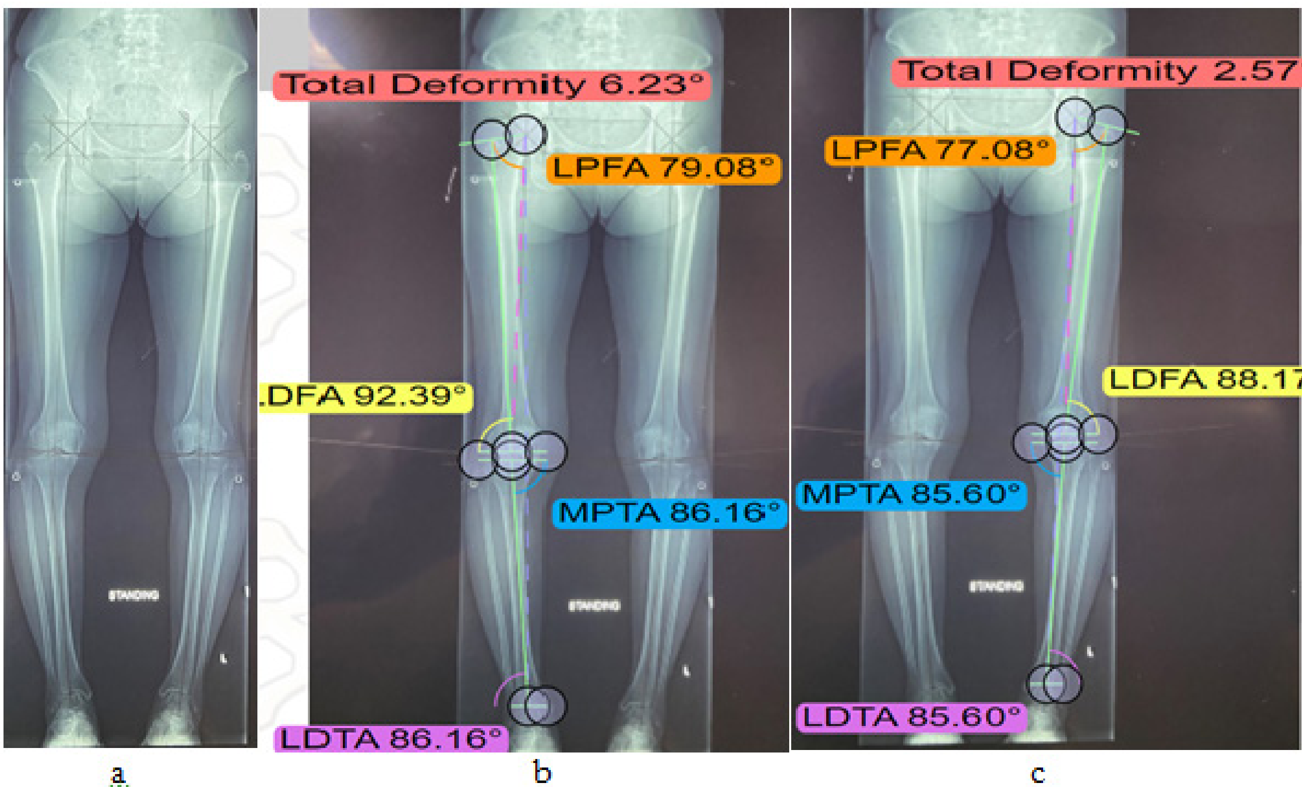


Figure 1: Example of digital long leg radiographs (LLRs) used in this study. a) Initial LLRs. b) Measurements of the LDFA and MPTA on the right lower limb with the Bonesetter app. c) Measurements of the LDFA and MPTA on the left lower limb with the Bonesetter app.
Note. LPFA: Lateral proximal femur angle. LDFA: Lateral distal femur angle. MPTA: Medial proximal tibial angle. LDTA: Lateral distal tibial angle.

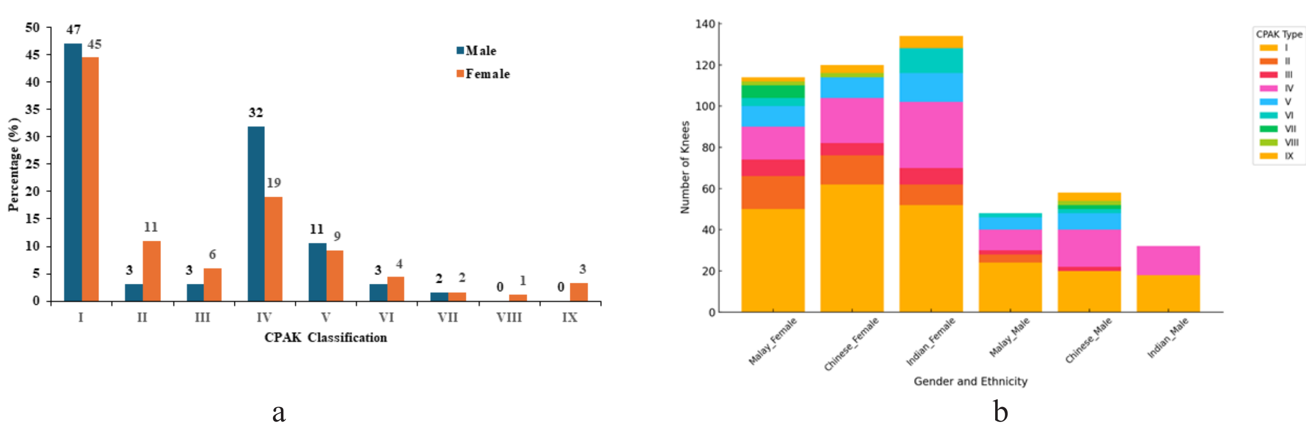


Figure 2: (a) Distribution(%) of CPAK classification among both the genders; (b) Distribution (N) of CPAK classification by Gender and Ethnicity.
Note. CPAK: Coronal plane alignment of the knee.

DISCUSSION

Dissatisfaction rates following TKA can be as high as 20% [11]. Common patient complaints included stiffness, instability, and persistent knee pain. Various factors have been attributed to these issues, including alignment philosophy, soft tissue injury, gap balancing, and unrealistic patient expectations. Improved counseling, preoperative optimization, and a better understanding of knee alignment have reduced the average dissatisfaction rate to 10% [12].

Previous studies consistently identified Type II CPAK as the most prevalent classification in both healthy and arthritic knees. However, the second most common classification varies, suggesting differences in patient populations, methodologies, or regional factors. Types I, IV, V, and VI were frequently observed, highlighting the diversity of CPAK patterns in arthritic knees. Research indicates variations in the CPAK classification between Asian and Western populations (Table 4) [2,4,7,13,14]. This study, which is the first to evaluate sex, and ethnic differences in CPAK classification among arthritic Malaysian knees, found that Type I was the most common (45.2%), followed by Type IV (22.4%) and V (9.6%). Type VIII is rare (0.8%). Similar results were observed across all sexes and ethnic groups.

Constitutional varus is more prevalent in the Malaysian population than in its Western counterparts. MacDessi *et al*., recommended anatomic alignment TKA for Type II, mechanical alignment TKA for Type V, and KA TKA for Types I, III, IV, and VI [2]. Given the predominance of Types I and IV (67.6%) in the arthritic Malaysian population, KA TKA may be more suitable for most patients. Determining the target alignment for each preoperative CPAK phenotype with reproducibility could improve patient reported outcome measures [15].

Table 4: Summary of findings of previous published studies regarding the most common CPAK types

Study	Year	Country	*N*	Most common CPAK
MacDessi *et al*. [2]	2020	Australia	500 healthy knees, 500 arthritic knees	Type II, followed by Type I and Type V
Hsu *et al*. [4]	2022	Taiwan	214 healthy knees	Type II, followed by Type I and Type VI
Toyooka *et al*. [13]	2023	Japan	500 arthritic knees	Type I, followed by type II, type III (8.2%),
Samant *et al*. [7]	2023	India	200 healthy knees 250 arthritic knees	Type II, followed by Type V and Type I
Coetzee *et al*. [14]	2024	South Africa	608 arthritic knees	Type III, followed by Type II and Type I
This study	2024	Malaysia	500 arthritic knees	Type I, followed by Type IV and V

This study had several limitations. First, potential errors in the rotation profile of the LLRs could have led to inaccurate angle measurements. To minimize the rotation profile errors in digital LLRs, two methods were employed, as described in the methodology section. To reduce inconsistencies in landmark interpretation, each angle was measured three times and the mean was used. The high intraclass correlation agreement between the researcher and radiologist for mHKA, MPTA, and LDFA angle measurements suggests that the methodology is reproducible in future studies [16]. Another limitation is the small sample size, although extrapolated from statistical calculations, which was constrained by the limited number of available patients. Despite inflating the initial calculation to 250, the sample size remained relatively small when considering the diversity of the Malaysian population. This limitation could affect the generalizability of our findings to a broader population. By excluding non-arthritic knees, this study overlooked potential variations in CPAK classification among individuals without arthritis. This restriction limits the scope of the findings and may not fully represent the CPAK distribution across all knee types. The inclusion criteria focusing solely on arthritic knees may have introduced selection bias. The sample may disproportionately represent individuals with more advanced joint degeneration or those seeking medical care, potentially skewing the results and their applicability to the general population. To mitigate these limitations in future research, a larger and more inclusive sample encompassing both arthritic and non-arthritic knees would provide a more comprehensive understanding of the CPAK classifications. Additionally, ensuring randomized or stratified sampling could help reduce the selection bias and enhance the representativeness of the findings.

CONCLUSION

Constitutional varus is more common in the Malaysian population than in their Western counterparts. Most arthritic Malaysian populations are better suited for KA TKA. This might shift the alignment principles for surgeons from mechanical to KA, particularly in patients with constitutional varus. Surgical outcomes can be optimized by understanding the typical CPAK distribution by tailoring surgical approaches, such as alignment principles and ligament balancing techniques, to better suit the inherent knee anatomy of Malaysian patients.

ACKNOWLEDGMENTS

We would like to thank the Director General of Health Malaysia for his permission to publish this article.

Institutional review board statement: The National Medical Research Registration (NMRR) for this study was NMRR ID-24-01759-L7C. This study was approved by the Medical Research Ethical Committee (MREC) of Malaysia with reference no 24-01759-L7C.

Data availability statement: The data for this study is available upon request from the authors.

Author contributions: All authors contributed to the study conception and design, material preparation, data collection, and analysis. The first draft of the manuscript was written by S.S., and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

ABBREVIATIONS

AA: anatomic Alignment; **aHKA**: Arithmetic hip-knee angle; **CPAK**: Coronal Plane Alignment of the Knee; **HIS**: Hospital Information System; **JLO**: Joint Line Obliquity; **KA**: Kinematic Alignment; **LDFA**: Lateral distal femur angle; **LLRs**: Long leg radiographs; **LPFA**: Lateral proximal femur angle; **MA**: Mechanical Alignment; **MDTA**: Medial distal tibia angle; **mHKA:** mechanical hip knee angle; **MPTA**: Medial proximal tibia angle; **MREC**: Medical Research and Ethics Committee's; **TKA:** total knee arthroplasty; **TKR**: Total Knee Replacement; **UKA**: unicondylar knee arthroplasty.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCE

1. Sappey-Marinier E, Batailler C, Swan J, Schmidt A, Cheze L, MacDessi SJ, *et al*., (2022). Mechanical alignment for primary TKA may change both knee phenotype and joint line obliquity without influencing clinical outcomes: a study comparing restored and unrestored joint line obliquity. Knee Surg Sports Traumatol Arthrosc 30:2806–2814.
2. MacDessi SJ, Griffiths-Jones W, Harris IA, Bellemans J, Chen DB. (2021). Coronal Plane Alignment of the Knee (CPAK) classification. Bone Joint J 103-B:329–337.
3. Mahfouz M, Abdel Fatah EE, Bowers LS, Scuderi G. (2012). Three-dimensional Morphology of the Knee Reveals Ethnic Differences. Clin Orthop Relat Res 470:172–185.
4. Hsu CE, Chen CP, Wang SP, Huang JT, Tong KM, Huang KC. (2022). Validation and modification of the Coronal Plane Alignment of the Knee classification in the Asian population. Bone Jt Open 3:211–217.
5. Usiskin I, Misra D. (2022). Racial Disparities in Elective Total Joint Arthroplasty for Osteoarthritis. ACR Open Rheumatol 4:306–311.
6. Singh L, Singh SS, Shihabudin TM, Singh PS, Musa AT, Mohd Daud N, *et al*., (2020). Morphological characteristics of Malaysian Malay shoulders for the Latarjet procedure: A cross-sectional CT scan based study. Curr Orthop Pract. 31:133–139.
7. Samant V, Desai M. (2023). Coronal plane alignment of knee joint (C.P.A.K) classification in Indian population-study of a new classification system in Indian knees. J Ortho Bone Disord 7:000250.
8. Paley D. Radiographic Assessment of Lower Limb Deformities. Chapter 3. Principles of Deformity Correction 2002; 31–60.
9. Nguyen HC, *et al*., (2022). A new protocol for obtaining whole leg radiographs with excellent reproducibility. J Cartilage Joint Preserv 2:100042.
10. Bonesetter App. [(accessed on 18 April 2020)]. Available online: https://detroitbonesetter.com/user/login
11. Husain A, Lee GC. (2015). Establishing Realistic Patient Expectations Following Total Knee Arthroplasty. J Am Acad Orthop Surg 23:707–13.
12. DeFrance MJ, *et al*., (2023). Are 20% of Patients Actually Dissatisfied Following Total Knee Arthroplasty? A Systematic Review of the Literature. J Arthroplasty 38:594–599.
13. Toyooka S, Osaki Y, Masuda H, Arai N, Miyamoto W, Ando S, *et al*., (2023). Distribution of Coronal Plane Alignment of the Knee Classification in Patients with Knee Osteoarthritis in Japan. J Knee Surg 36:738–743.
14. Coetzee K, Charilaou J, Burger M, Jordaan J. (2024). Increased prevalence of valgus constitutional alignment subtypes in a South African arthritic population group using the coronal plane alignment of the knee (CPAK) classification. Knee 49:158–166.
15. Konishi T, Hamai S, Tsushima H, Kawahara S, Akasaki Y, Yamate S, *et al*., (2024). Pre- and postoperative Coronal Plane Alignment of the Knee classification and its impact on clinical outcomes in total knee arthroplasty. Bone Joint J 106-B:1059–1066.
16. Koo TK, Li MY. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 15:155–163.