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Restoring coronal pre-arthritic alignment in mobile-bearing unicompartmental knee arthroplasty: mid- to long-term outcomes

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Abstract

Background Previous research suggests that restoring pre-arthritic alignment in fixed-bearing unicompartmental knee arthroplasty (UKA) can improve postoperative knee function. However, its applicability to mobile-bearing UKA remains unclear. This study evaluated whether patients who achieve pre-arthritic alignment following mobile-bearing UKA with the kinematic alignment technique experience superior postoperative knee function compared with those who do not.

Methods A retrospective analysis was conducted on 236 knee joints that underwent UKA using kinematic alignment techniques between May 2015 and November 2017. Of these, 222 knee joints met the inclusion criteria for the study. Postoperative outcomes were assessed, with pre-arthritic alignment determined using the arithmetic hip-knee-ankle angle (aHKAA). Postoperative alignment within ±3° of the aHKAA was classified as pre-arthritic alignment. Patients were categorized into two groups: pre-aligned and non-pre-aligned. Final follow-up occurred in September 2024, and outcome measures included the visual analogue scale (VAS) score, Hospital for Special Surgery (HSS) score, and Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales for daily living, sports, and survivorship. Additionally, the percentage of patients meeting the patient-acceptable symptom state (PASS) criteria for KOOS-related subscales was recorded. Failure was defined as conversion to total knee arthroplasty.

Results Among the 222 knee joints analyzed, the average follow-up time was 8.65 years (range: 7–9 years), with an average implant survival time of 8.48 years and a total knee arthroplasty conversion rate of 2.7%. The 5-year survival rate was significantly higher in the pre-arthritically aligned group (99.4%) than in the non-pre-arthritically aligned group (92.5%) ($p=0.012$). In total, 169 knees (76.13%) were classified as pre-arthritically aligned, while 53 knees (23.87%) were non-pre-arthritically aligned. postoperative VAS scores significantly improved from 6.90 ± 0.82 to 0.58 ± 0.56 ($p<0.001$), and HSS scores increased from 56.3 ± 8.36 to 92.39 ± 4.54 ($p<0.001$). Although no significant differences in postoperative VAS scores were observed between groups ($p=0.147$), the pre-arthritically aligned

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group demonstrated significantly higher HSS scores and better KOOS subscale scores for daily living activities, sports, and quality of life than the non-pre-arthritically aligned group (all $p < 0.01$). The PASS ratio for KOOS subscales also indicated superior outcomes in the pre-arthritically aligned group.

Conclusion Using the kinematic alignment technique for mobile-bearing UKA, knees that achieved pre-arthritic alignment demonstrated superior survivorship and subjective postoperative knee function compared with those that did not.

Keywords Unicompartmental knee arthroplasty, Surgical technique, Pre-arthritic alignment

Introduction

Unicompartmental knee arthroplasty (UKA) has emerged as a preferred treatment for anteromedial osteoarthritis (OA) of the knee [1, 2]. The prevalence of UKA procedures has significantly increased in recent years [3–5]. UKA aims to replace the damaged and symptomatic compartment while resurfacing the joint and preserving both cruciate ligaments, resulting in reduced trauma and accelerated recovery [6].

Correcting knee alignment following UKA plays a crucial role in optimizing knee function and long-term outcomes [7]. Advances in understanding knee joint anatomical variation have led to efforts to restore patients' native, or pre-arthritic, alignment. The kinematic alignment principle has been adopted by some practitioners in UKA, focusing on restoring the knee's pre-arthritic coronal alignment to optimize postoperative outcomes [8–10]. Recent studies suggest that in fixed-bearing UKA, aligning the knee to its pre-arthritic position can enhance postoperative function. For example, Plancher et al. found that patients whose postoperative knee angle fell within 3° of their pre-arthritic alignment demonstrated superior joint function at a 10-year follow-up [11]. Similarly, Bayoumi et al., in a retrospective analysis of 537 robot-assisted medial UKA cases, reported that knees restored to their pre-arthritic angle, as well as those with mild overcorrection, showed improved mid-term functional outcomes and prosthesis survival [12].

However, there is currently a lack of studies exploring the relationship between restoring pre-arthritic alignment and postoperative function in mobile-bearing UKA. This study was performed to investigate alignment outcomes in patients undergoing mobile-bearing UKA using kinematic alignment techniques, comparing mid- to long-term knee function between those who achieve pre-arthritic alignment and those who do not.

Methods

Study design

Based on the approval of the Institutional Review Committee (2022-KY-253), data were collected on 236 knee joints following the use of an extramedullary technique for medial mobile Oxford UKA performed by the senior surgeon between May 2015 and November 2017. The indications for UKA were anteromedial OA, intact knee ligaments, flexion contracture of < 15°, preserved knee range of motion, and a varus deformity of < 15° that was correctable [13, 14]. The inclusion criteria were treatment with primary UKA using the kinematic alignment technique for anteromedial OA and the availability of standardized, complete radiographic records, including preoperative and postoperative long-leg radiographs as well as weight-bearing anteroposterior and lateral knee radiographs. The exclusion criteria were a history of femoral or tibial fracture on either side, poor or incomplete radiographic records, loss to follow-up during the study, death during follow-up, or an estimated pre-arthritic alignment in valgus. After applying these exclusion criteria, 222 knees were included in the study (Fig. 1).

Implant and technique

All UKA surgeries were performed by the same experienced surgeon using the novel extramedullary technique introduced by our team in 2020 [15]. The tibial cut was performed using the extramedullary technique following the Oxford UKA manual guide method. The cut was made in the flexion position, establishing an approximately 7-mm flexion gap (corresponding to the thickness of the tibial baseplate plus the meniscus bearing). The femur was then prepared using the kinematic alignment approach. A spacer block was inserted into the flexion gap to fully fill the medial compartment with the knee at 90° of flexion in the supine position. The spacer block was typically 7 mm thick to restore medial collateral ligament tension. A centerline for the femoral component was then drawn on the articular surface of the distal femoral condyle (Fig. 2).

The line was drawn perpendicular to the tibial bone cutting plane. It extended from the midpoint of the tibial cutting plane to the anterior of the femoral condyle, representing the centerline of the femoral component and marking the center of its surface. This ensured the femoral component aligned consistently with the centerline of the tibial component during flexion motion. Next, the knee joint was extended, and a thicker spacer block was inserted into the medial compartment to fully fill the extension gap. This thicker spacer block restored medial collateral ligament tension and corrected the

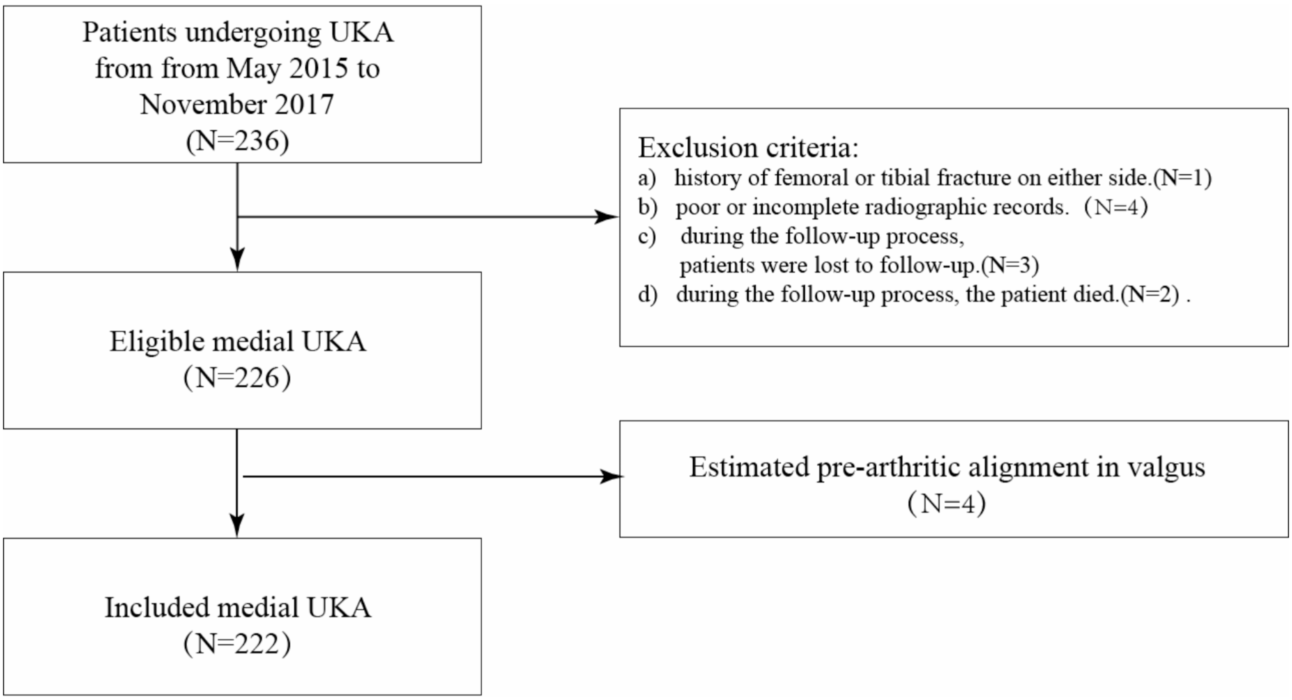

Fig. 1 Flowchart of patient inclusion

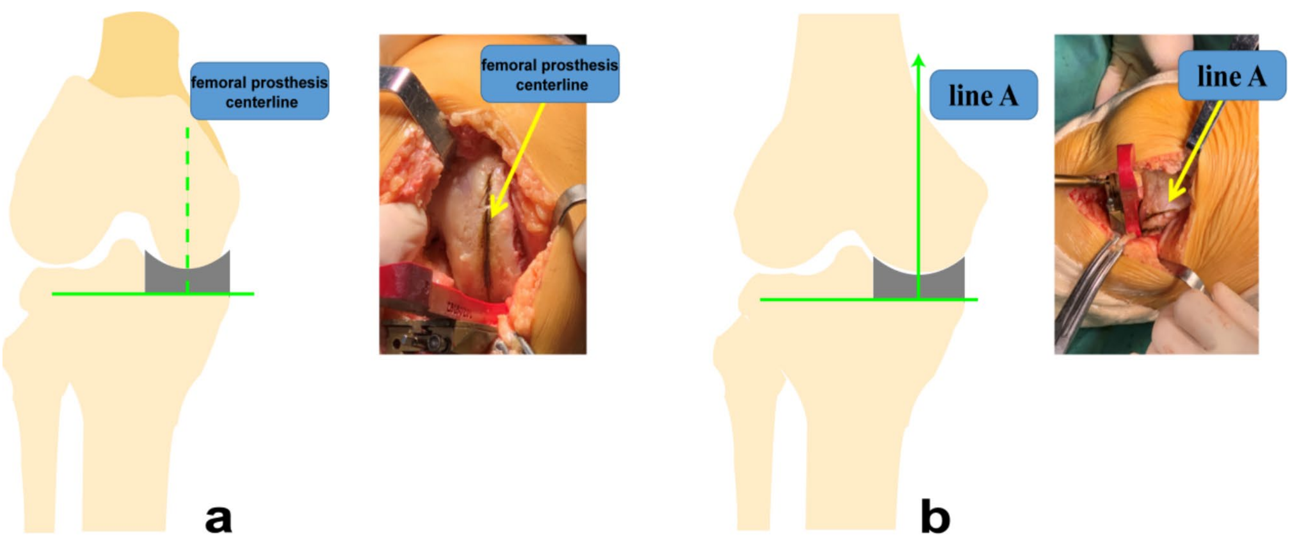

Fig. 2 Schematic diagram and intraoperative markings for kinematic alignment in Oxford UKA. The medial compartment was fully filled with a spacer block to restore the tension of the medial collateral ligament during knee flexion. A vertical line, perpendicular to the tibial cut plane, was drawn on the articular surface of the distal medial femoral condyle, starting from the midpoint of the tibial cut plane. This vertical line represents the kinematic center line of the femoral prosthesis. During knee extension, the medial compartment was fully filled with a thicker spacer block, and the leg alignment was restored to its natural state before osteoarthritis. Another vertical line (Line A), also perpendicular to the tibial cut plane, was drawn on the femoral condyle starting from the midpoint of the tibial cut plane. Line A is used as the reference for the direction of femoral drilling

varus deformity in the extension position. The spacer block used in the extension position was typically 1 to 2 mm thicker than the one used in the flexion position. A vertical line (line A), perpendicular to the tibial cut plane, was drawn on the anterior surface of the femoral condyle, originating from the midpoint of the tibial cut plane. Line A served as a reference for the direction of femoral drilling, ensuring that the axis of the femoral prosthesis in the extension position remained perpendicular to the tibial prosthesis plane. Once the reference line was established, a femoral drill guide was inserted at 90° of knee flexion and attached to the distal femur, with its bottom resting on the tibial cut surface. It was then verified that the drill hole was centered on the medial femoral condyle

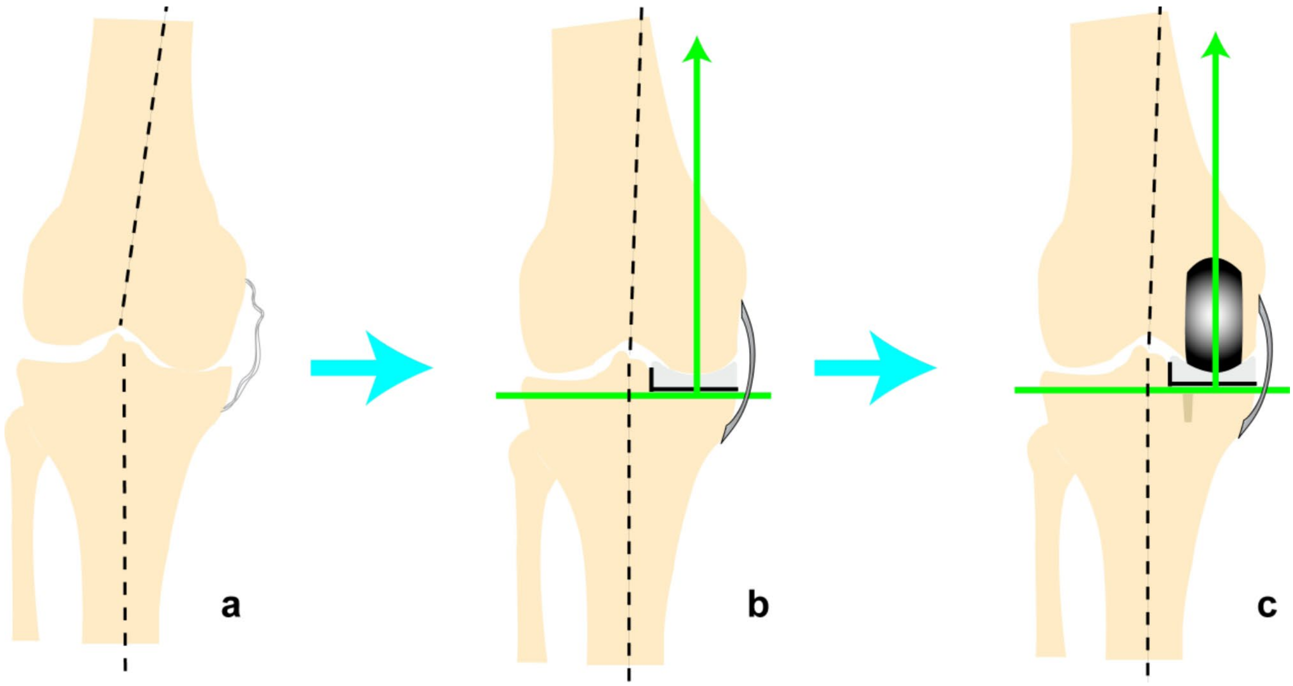

Fig. 3 Kinematic alignment technique in accordance with the design principles of Oxford UKA

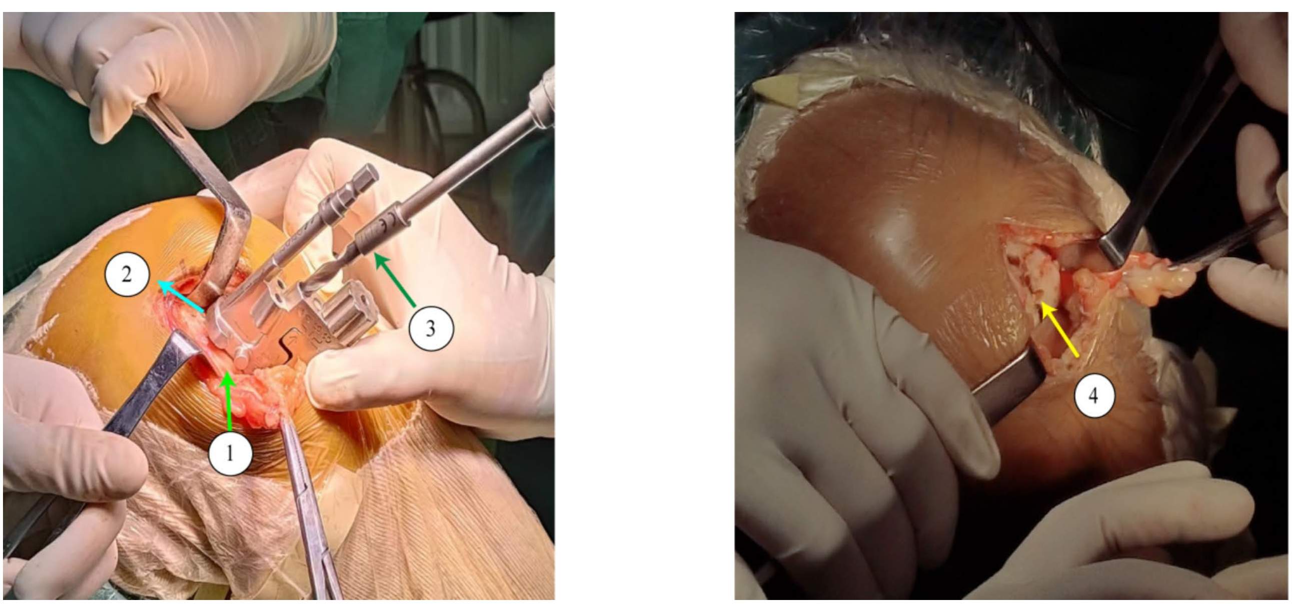

Fig. 4 Key aspects of the kinematic alignment technique. ① The femoral drill guide must be positioned against the distal femur at 90° of knee flexion, with its bottom surface closely seated on the tibial cut plane. ② The drilling direction must be parallel to Line A. ③ Verify that the drill holes are aligned with the central line of the distal femoral condyle through the visual inspection windows. ④ Ensure that the hole is located on the central line of the articular surface of the distal femoral condyle

through the drill guide window and that the drilling direction was parallel to Line A. Once confirmed, 4- and 6-mm holes were drilled through the guide. The posterior femoral condyle was resected using the posterior femoral condyle resection guide. A femoral spherical mill was then employed to mill the distal femoral condyle, balancing the flexion and extension gaps. After achieving this balance, the tibial keel was prepared, and the prosthesis was fixed using bone cement (Figs. 3 and 4).

A spacer block was inserted to fully fill the medial compartment, restoring the tension of the medial collateral ligament. A reference line for the femoral axis was then drawn perpendicular to the tibial cut plane. This ensured that the femoral prosthesis was implanted relative to the tibial prosthesis, achieving proper prosthesis alignment. This intuitive and straightforward reference method facilitates accurate prosthesis implantation.

Radiographic assessment

Prior to surgery, all patients underwent standardized weight-bearing anteroposterior and lateral radiographs of the knee joint, as well as weight-bearing long-leg radiographs. Three days after the surgery, the same set of radiographic examinations was repeated for all patients.

The hospital's Picture Archiving and Communication System (PACS) was used to measure preoperative and postoperative indicators, including the hip-knee-ankle angle (HKAA), lateral distal femoral angle (LDFA), and medial proximal tibial angle (MPTA). Preoperatively, the HKAA is the angle between the tibial mechanical axis and the femoral mechanical axis, while the MPTA is the angle between the tangent of the medial and lateral tibial plateaus and the tibial mechanical axis (Fig. 5). The LDFA is the angle between the tangent of the medial and lateral femoral condyles and the femoral mechanical axis (Fig. 5) [16–18].

Two orthopedic doctors utilized the hospital's PACS imaging system and ImageJ software for measurements. One orthopedic surgeon (Y.K.J.) randomly selected 40 knees and performed measurements twice, with a one-week interval, to assess intra-rater reliability. The second orthopedic surgeon (C.Q.L.) conducted two independent measurements on the same 40 knee joints, also spaced 1 weeks apart, to assess inter-rater reliability. The measurements from both surgeons were then compared to evaluate both intra- and inter-rater reliability.

Measurements of pre-arthritic alignment

The arithmetic HKAA (aHKAA) was used to estimate the pre-arthritic alignment. The calculation formula for aHKAA in this study was: 180° + MPTA – LDFA (Fig. 5). If the patient's postoperative HKAA fell within one standard deviation (± 3°) of their preoperative aHKAA, the patient was considered to have achieved pre-arthritic

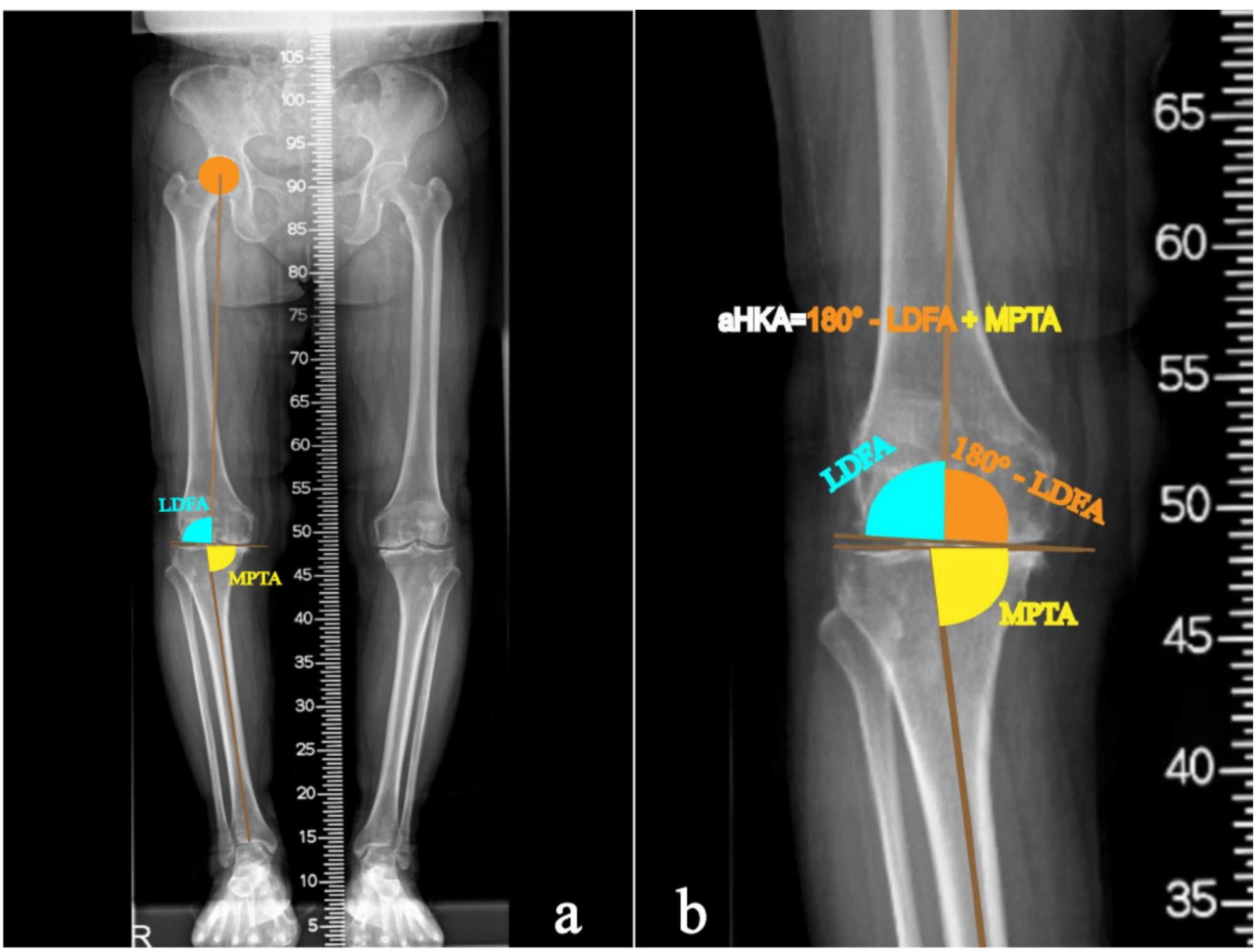

Fig. 5 Measurement of the arithmetic hip-knee-ankle angle (aHKAA). (**a**) Preoperative weight-bearing long-leg radiograph showing the mechanical lateral distal femoral angle (LDFA) and the mechanical proximal tibial angle (MPTA). (**b**) Magnified view of the preoperative radiograph highlighting the measurement. The aHKAA was calculated using the formula 180°+ MPTA – LDFA

Table 1 Patient demographic and radiological parameters

Variables	Total (n = 222)
Age (years)	65.80 ± 8.19
Sex (n (%))	
Female	149(75.25%)
Male	49(24.75%)
Side (n (%))	
Right	104(46.85%)
Left	118(53.15%)
BMI (kg/m2)	26.88 ± 3.38
Radiological parameters	
Preoperative HKA (°)	173.48 ± 2.83
LDFA (°)	88.26 ± 2.44
MPTA (°)	86.01 ± 2.76
aHKAA (°)	177.75 ± 3.79
Postoperative HKA (°)	177.53 ± 2.44

Data are presented as mean ± standard deviation or n (%)

BMI: body mass index, HKAA: hip-knee-ankle angle, LDFA: mechanical lateral distal femoral angle, MPTA: mechanical proximal tibial angle, aHKAA: arithmetic hip-knee-ankle angle

alignment [18, 19]. Based on the presence of pre-arthritic alignment after surgery, the knees were divided into two groups: pre-arthritically aligned (postoperative HKAA restored within ± 3.0° of the aHKAA) and non-pre-arthritically aligned (postoperative HKAA restored beyond ± 3.0° of the aHKAA).

Patient-reported outcome measures

Visual analogue scale (VAS) scores before and after surgery, Hospital for Special Surgery (HSS) scores, and postoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) subscale scores for daily living activities, sports, and quality of life were collected, including achievement of the patient-acceptable symptom state (PASS) [20–22]. Previously reported PASS values for the KOOS subscales included daily living activities (87.5), exercise (43.8), pain (87.0), and quality of life (66.0) [20].

Statistical analysis

The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Results for normally distributed data were reported as mean and standard deviation. For continuous variables meeting normality assumptions (e.g., body mass index [BMI], LDFA, MPTA, and aHKAA), comparisons between groups were performed using Student's t-test. Non-normally distributed continuous variables were analyzed using the Mann–Whitney U test. Categorical variables are presented as frequency and percentage, with intergroup comparisons conducted using the chi-square test or Fisher's exact test, as appropriate. Implant survivorship was assessed using the Kaplan–Meier method, with conversion to total knee arthroplasty defined as the endpoint.

The imaging parameter aHKAA was considered statistically significant when the difference between the two groups was 1.5°, with an expected standard deviation of 2.5° [23]. To calculate the sample size and perform a prior efficacy analysis, G*Power 3.1 (Heinrich Heine University, Düsseldorf, Germany) was used. With a significance level (α) set to 0.05 and a confidence level (1 − β) of 0.8, a minimum sample size of 52 patients was required for each group. It was confirmed that the number of patients included in this study met the sample size requirement. Statistical analysis was performed using SPSS 25.0 software, and a p value of < 0.05 (two-sided) was considered statistically significant.

Results

Patient demographics

A total of 222 knee procedures were included in this study. Patient demographics, including age, sex, BMI, and radiological parameters (preoperative and postoperative HKAA, LDFA, MPTA, and aHKA), are summarized in Table 1.

Preoperative and postoperative measurements demonstrated high intra-observer and inter-observer reliability, as summarized in Table 2.

Grouping based on postoperative HKAA and aHKAA

A postoperative HKAA within ± 3° of the aHKAA was defined as pre-arthritic alignment. Patients were categorized into two groups: the pre-arthritically aligned group and the non-pre-arthritically aligned group. Among the 222 knee joints, 169 (76.1%) were classified as pre-arthritically aligned, while 53 (23.9%) were not, as shown in Fig. 6.

No statistically significant differences were observed between the two groups in baseline characteristics,

Table 2 Intra-observer and inter-observer reliability

Variables	Intra-observer			Inter-observer		
	ICC	95% CI	p value	ICC	95% CI	p value
Preoperative HKAA (°)	0.897	0.813–0.945	<0.001	0.881	0.738–0.942	<0.001
LDFA (°)	0.885	0.793–0.938	<0.001	0.871	0.741–0.934	<0.001
MPTA (°)	0.917	0.849–0.955	<0.001	0.901	0.790–0.950	<0.001
Postoperative HKAA (°)	0.848	0.731–0.917	<0.001	0.848	0.731–0.917	<0.001

ICC: intraclass correlation coefficient, CI: confidence interval, HKAA: hip-knee-ankle angle, LDFA: mechanical lateral distal femoral angle, MPTA: mechanical proximal tibial angle

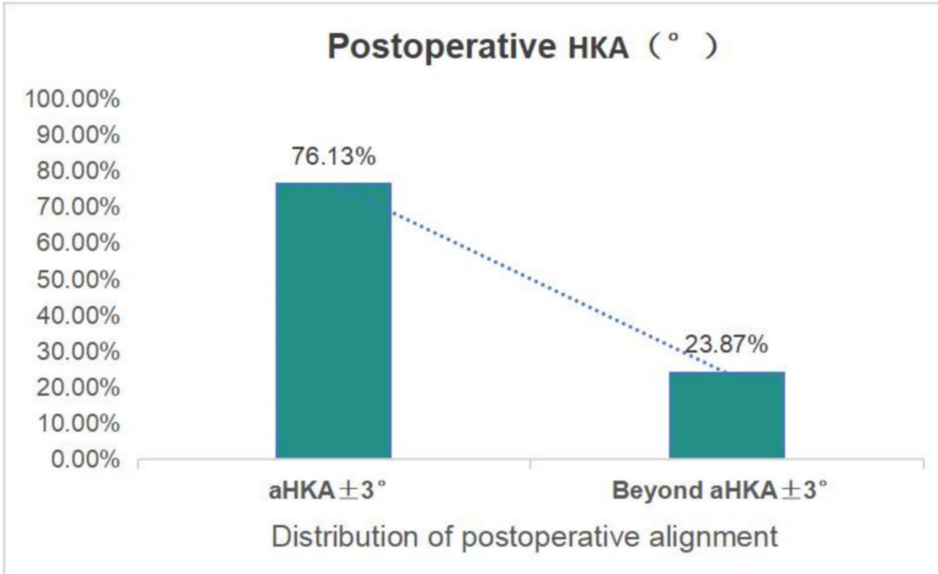

Fig. 6 Alignment categories of pre-arthritic and non-pre-arthritic knees following medial unicompartmental knee arthroplasty. Pre-arthritic alignment was estimated using the arithmetic hip-knee-ankle angle (aHKAA). Postoperative hip-knee-ankle angle (HKAA) values deviating beyond ±3° from the pre-arthritic aHKAA alignment were classified as non-pre-arthritically aligned knees

including sex, age, weight, height, and BMI ($p > 0.05$), as detailed in Table 3.

Implant survival

The overall mean implant survival time was 8.5 years. The mean survival time in the pre-arthritically aligned group was 8.6 years, and that in the non-pre-arthritically aligned group was 8.1 years ($p = 0.04$). Kaplan–Meier survival curves are presented in Fig. 7.

At 5 years, the implant survival rate was 99.4% in the pre-arthritically aligned group and 92.5% in the non-pre-arthritically aligned group.

Patient-reported outcome measures

Preoperatively, the mean VAS score was 6.9 ± 0.8 and the mean HSS score was 56.3 ± 8.4. At the final follow-up, both the VAS and HSS scores showed significant improvements from the preoperative values ($p < 0.05$). Comparative analysis revealed no significant differences in the postoperative VAS scores between the groups. However, the pre-arthritically aligned group demonstrated significantly higher postoperative HSS scores and superior outcomes on the KOOS subscales for daily living, sports, and quality of life compared with the non-pre-arthritically aligned group (Table 3).

Patient satisfaction

The proportion of patients meeting the PASS criteria for the KOOS subscales was significantly higher in the pre-arthritically aligned group than in the non-pre-arthritically aligned group. Specifically, 86.4% of the pre-arthritically aligned group met the PASS criteria for KOOS activities of daily living and 89.4% met the PASS criteria for KOOS sports, compared with 35.9% ($p < 0.01$) and 66.0% ($p < 0.01$), respectively, in the non-pre-arthritically aligned group (Fig. 8).

Discussion

This study showed that knees achieving pre-arthritic alignment demonstrated superior joint function during the medium- to long-term follow-up compared with those that did not. Understanding the constitutional alignment of the lower limbs is essential in UKA. Historically, two main concepts have guided the positioning of UKA components: the traditional mechanical alignment principle, commonly used in total knee arthroplasty [10], and the emerging approach of kinematic alignment. Recent research indicates that the distribution of lower limb alignment angles in the normal population is not uniform, with typical alignments often falling within a varus range of 2° to 3° [24, 25]. This study cohort exhibited a wide distribution of alignment angles, including cases exceeding the inversion angle by 2° to 3°. Failing to account for individual knee joint conditions when applying mechanical alignment techniques can lead to significant anatomical and kinematic changes, potentially adversely affecting long-term outcomes. Consequently, the principle of kinematic alignment, which seeks to restore a patient's natural joint alignment, is gaining traction [26]. This concept involves guiding postoperative alignment based on the pre-arthritic alignment angle, emphasizing the preservation of the knee's physiological

Table 3 Patient demographic, radiographic, and PROM outcomes by alignment group

Variables	Pre-arthritically aligned	Non-pre-arthritically aligned	*p* value
N(knee)	169(76.13%)	53(23.87%)	
Age (years)	65.88 ± 7.79	65.55 ± 9.43	0.651[b]
Sex (n (%))			
Female	114(73.55%)	40(78.43%)	0.390[c]
Male	41(26.45%)	11(21.57%)	
Side (n (%))			
Right	78(46.15%)	26(49.06%)	0.712[c]
Left	91(53.85%)	27(50.94%)	
Height (cm)	161.61 ± 6.78	161.16 ± 7.26	
Weight (kg)	70.80 ± 11.36	68.56 ± 9.30	
BMI (kg/m2)	26.97 ± 3.51	26.56 ± 2.84	0.437[a]
Preoperative HKAA (°)	173.48 ± 2.71	173.49 ± 3.23	0.677[b]
LDFA (°)	88.24 ± 2.24	88.31 ± 3.01	0.852[a]
MPTA (°)	85.89 ± 2.42	86.39 ± 3.65	0.352[a]
aHKAA (°)	177.65 ± 3.05	178.07 ± 5.53	0.591[a]
Postoperative HKAA (°)	177.62 ± 2.31	177.25 ± 2.83	0.560[b]
PRE-HSS	56.24 ± 8.50	56.49 ± 7.99	
POST-HSS	92.84 ± 4.24	90.94 ± 5.18	0.002[b]
PRE-VAS	6.90 ± 0.81	6.89 ± 0.87	0.933[b]
POST-VAS	0.54 ± 0.5	0.72 ± 0.69	0.147[b]
KOOS ADL(87.5)	91.80 ± 5.44	78.36 ± 12.25	<0.001[a]
KOOS Sport(43.8)	75.88 ± 14.91	62.40 ± 22.52	<0.001[a]
KOOS Qol(66)	83.07 ± 9.30	73.68 ± 15.43	<0.001[a]

Data are reported by alignment group and presented as mean ± standard deviation or n (%)

BMI: body mass index, HKAA hip-knee-ankle angle, LDFA: mechanical lateral distal femoral angle, MPTA: mechanical proximal tibial angle, aHKAA: arithmetic hip-knee-ankle angle, HSS: Hospital for Special Surgery

[a]Student's t-test

[b]Mann–Whitney U test

[c]Chi-square test

structure to enhance patient satisfaction [10, 11]. We employed the aHKAA method, as outlined in the study by MacDessi et al., to calculate pre-arthritic alignment, adhering closely to kinematic alignment principles [19]. Restoring pre-arthritic alignment offers several theoretical benefits, including reduced postoperative stiffness, improved load distribution, and enhanced functional outcomes [27–30].

Recent studies emphasize the critical role of proper limb alignment in ensuring the long-term success of UKA. Slaven et al. [31, 32] highlighted that overall limb alignment, rather than component alignment, significantly influences functional outcomes and implant survival. In their 2021 study, Slaven et al. demonstrated that patients with medial fixed-bearing UKA who achieved optimal limb alignment exhibited significantly improved functional outcomes, while poor alignment was associated with a higher risk of complications [32]. In their earlier work, coronal alignment was identified as the most significant predictor of revision rates in medial fixed-bearing UKA, with slight varus alignment regarded as the ideal postoperative position [31]. Furthermore, Kennedy et al. confirmed that functional outcomes and revision rates in Oxford medial UKA are independent of component alignment but strongly correlated with overall limb alignment. These findings underscore the importance of restoring a slight varus alignment, reflective of the patient's pre-arthritic state, to achieve favorable outcomes and implant longevity [33].

These studies align with our findings, reinforcing the growing consensus that restoring a slight varus alignment post-UKA is optimal for both functional outcomes and implant survival. At the final follow-up, patients whose postoperative alignment was within 3° of their

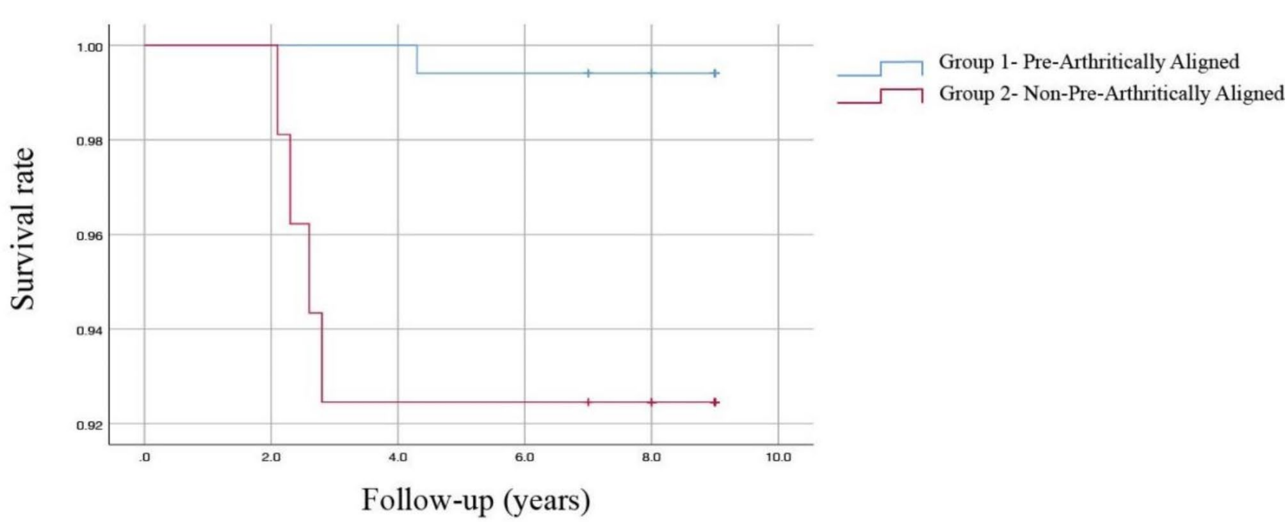

Fig. 7 Kaplan–Meier survival curve illustrating the cumulative survival probability following unicompartmental knee arthroplasty, with total knee arthroplasty revision as the endpoint

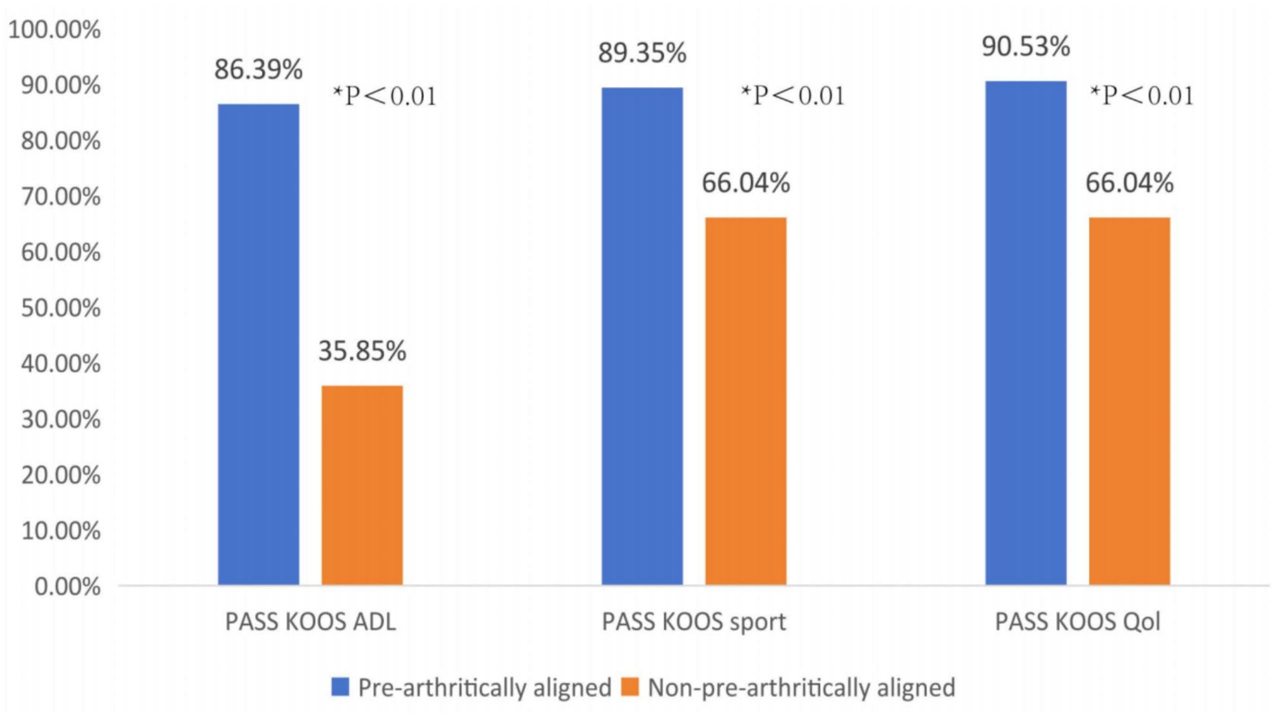

Fig. 8 Percentages of patients reaching patient-acceptable symptom state (PASS) for KOOS subscores. The bar graphs depict the proportion of patients in each cohort achieving the PASS for each KOOS subscale. The pre-arthritically aligned group had a significantly higher percentage of patients meeting the PASS criteria across all subscales ($p < 0.01$)

pre-arthritic alignment demonstrated higher HSS scores and KOOS scores for activities of daily living, sports, and quality of life, along with a greater proportion achieving the PASS criteria for these subscales. Compared with previous studies, such as those by Plancher et al., which showed that 85% of patients achieved pre-arthritic alignment with high PASS rates for KOOS [11], our study showed that 76.13% of patients reached pre-arthritic alignment. Additionally, 86.39% and 89.35% of these patients met the KOOS PASS criteria for daily living and sports, respectively. Notably, the proportion of patients not achieving kinematic alignment who still met the KOOS PASS criteria was higher than reported by Plancher et al. This difference may be attributed to the unique design of the mobile-bearing prosthesis used in our study, which emulates the function of the meniscus in healthy knees [34]. The meniscus adjusts its height and thickness in accordance with the contours of the femoral and tibial surfaces, moving passively between them, thus allowing for a tolerable minor malalignment of components [34]. Similarly, Kim et al. retrospectively analyzed 164 patients who underwent UKA and evaluated postoperative patient-reported outcome measures based on changes in the coronal plane alignment of the knee classification. Their results indicated that preserving the native coronal plane alignment of the knee during UKA surgery is crucial for achieving good clinical outcomes 1 year after surgery [35]. Additionally, we observed a 5-year survival rate of 99.4% for patients whose postoperative alignment was within 3° of their pre-arthritic alignment, exceeding survival rates for those outside this range. This finding aligns with the results obtained by Bayoumi et al., who reported 5-year survival rates of 90.5% for undercorrected knees and 98.6% for knees restored to pre-arthritic alignment [12]. These findings suggest that restoring alignment to pre-arthritic standards can lead to favorable implant survival rates. However, further investigation is needed to better understand the underlying mechanisms and provide additional clinical evidence.

The kinematic alignment technique employed in this study is a novel extramedullary approach based on the principles of Oxford UKA. The mid-term follow-up results are promising, demonstrating improved precision in femoral prosthesis positioning and optimal postoperative bearing motion trajectories, which reduces the incidence of bearing dislocation [15]. This technique effectively restores knee joint kinematics by aligning the femoral implant with the tibia, returning the joint to its pre-OA state.

This study had several limitations. First, it was a retrospective analysis without a control group, lacking direct comparisons with other alignment strategies. Future prospective, multi-center, large-sample, long-term controlled trials are needed to comprehensively evaluate this technique. Second, all procedures were performed by a highly experienced senior surgeon, which may limit the generalizability of these results to less experienced practitioners. Third, this preliminary report is based on a relatively small sample size and mid-term follow-up, requiring additional data to validate the findings.

Conclusion

Knees that are pre-arthritically aligned (within 3.0° of the aHKAA) demonstrate enhanced joint function and superior survivorship after undergoing mobile-bearing UKA with the kinematic alignment technique, compared with those that are not pre-arthritically aligned.

Abbreviations

aHKAA	Arithmetic hip-knee-ankle angle
BMI	Body mass index
HKAA	Hip-knee-ankle angle
HSS	Hospital for Special Surgery
KOOS	Knee Injury and Osteoarthritis Outcome Score
LDFA	Lateral distal femoral angle
MPTA	Medial proximal tibial angle
OA	Osteoarthritis
PACS	Picture Archiving and Communication System
PASS	Patient-acceptable symptom state
UKA	Unicompartmental knee arthroplasty
VAS	Visual analogue scale

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Author contributions

Yankun Jiang, Changquan Liu, and Guoyuan Sun designed the study. Cheng Huang, Changquan Liu, Nianfei Zhang, and Ran Ding collected the data. Yankun Jiang and Changquan Liu performed the data analysis. Yankun Jiang drafted the manuscript, while Weiguo Wang, Qidong Zhang, and Wanshou Guo revised it. All authors contributed to the manuscript's development and have approved the final version.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All methods in this study were carried out in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All protocols were approved by the ethics committee of China-Japan Friendship Hospital. The approval number is 2022-KY-253. Informed written consent was provided by every participant.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable. This is a retrospective clinical study; therefore, clinical trial registration is not applicable.

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