Pre-Arthritic/Kinematic Alignment in Fixed-Bearing Medial Unicompartmental Knee Arthroplasty Results in Return to Activity at Mean 10-Year Follow-up

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Background: The optimal alignment strategy in unicompartmental knee arthroplasty (UKA) is debated. Recent studies have suggested that kinematic alignment may lead to improved biomechanics and outcomes. The aim of the present study was to determine if pre-arthritic/kinematic alignment of knees would result in sustained long-term restoration of function, without conversion to total knee arthroplasty (TKA), following non-robotically assisted, fixed-bearing medial UKA.

Methods: A total of 236 UKAs were performed from 2000 to 2015. Of these, a total of 150 medial UKAs met the inclusion criteria and were included in the study. There were 76 UKAs performed in female patients. The mean age was 65 ± 10 years and the mean body mass index was 28.6 ± 5 kg/m^2. Patients with ≥15° of varus alignment preoperatively were excluded. Varus deformity was evaluated with use of the hip-knee-ankle angle (HKAA). Pre-arthritic/kinematic alignment was estimated with use of an arithmetic HKAA (aHKA, calculated as the medial proximal tibial angle minus the lateral distal femoral angle). We defined pre-arthritic/kinematic alignment as a postoperative HKAA within 3° of the aHKA. The primary outcome measures were the Knee Injury and Osteoarthritis Outcome Score (KOOS) Activities of Daily Living and Sport subscales, including the percentage of patients who met the patient acceptable symptom state (PASS) for these measures. Failure was defined as conversion to TKA.

Results: The mean follow-up was 10 years (range, 4 to 20 years), with a mean survival time estimate of 18.3 years (95% confidence interval [CI], 17.8 to 18.8). The rate of conversion to TKA was 3% (5 of 150 UKAs). Postoperatively, 127 (85%) of 150 knees were pre-arthritic/kinematically aligned, and 23 knees (15%) were not. Patients with compared to those without pre-arthritic/kinematically aligned knees had significantly longer mean survival (18.6 years; 95% CI, 18.2 to 19) compared with 15.4 years; 95% CI, 13.4 to 17.5, respectively; p = 0.008) and higher KOOS Activities of Daily Living (92 compared with 74; p < 0.001) and Sport subscale scores (74 compared with 36; p < 0.001). A greater proportion of knees in the pre-arthritic/kinematically aligned cohort met the PASS for the KOOS Activities of Daily Living (85%, 106 of 125 knees) and Sport subscales (109 of 125, 87%) compared with the non-pre-arthritic/kinematically aligned cohort (28% and 57%, respectively; p < 0.01).

Conclusions: Pre-arthritic/kinematically aligned knees in this non-robotically assisted fixed-bearing medial UKA cohort had superior outcomes, including the KOOS Activities of Daily Living and Sport subscales and achievement of the PASS for these measures, compared with non-pre-arthritic/kinematically aligned at an average of 10 years after UKA. Knees that fell within 3° of a simple aHKA measurement on a 3-foot (1-m)-long standing radiograph had greater longevity and return to activities.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Optimal alignment in knee arthroplasty continues to be debated in the literature. Mechanical alignment has traditionally been considered the so-called gold standard, with the goal of restoring a neutral hip-knee-ankle angle (HKAA). However, an improved understanding of anatomic variations and lower-limb biomechanics, and literature suggesting alignment beyond the limits of 0° to 3° of varus does not impact prosthesis longevity has led some to question the use of this technique[1-4].

Vasso et al. have shown that minor varus alignment yields better results compared with neutral or near-neutral alignment in medial UKAs[4]. Zuiderbaan et al. reported no

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/G996).

failed medial UKA in knees with an HKAA of 10° to 15° of varus preoperatively or in knees with an HKAA of >4° of varus postoperatively[5].

Variability in limb alignment has been demonstrated in the literature. Nearly one-third of healthy adults have been shown to exhibite a lower-limb alignment in varus[2]. Creating a neutral mechanical axis in patients with a constitutionally varus knee may limit postoperative return to activity. Substantial anatomic modifications and alterations in soft-tissue balance and joint orientation with subsequent altered knee kinematics have been shown to decrease implant longevity[6,7].

The use of the pre-arthritic alignment angle as a guide for postoperative alignment has been described as kinematic alignment. This kinematic approach is believed to restore soft-tissue tensioning, maintain collateral ligament balance, and preserve 3-dimensional knee kinematics[6,8]. Several authors have correlated the restoration of constitutional alignment in total knee arthroplasty (TKA) with improved return to activity in kinematically aligned knees compared with mechanically aligned knees[9-13]. This thesis was further supported in a 2020 meta-analysis, which demonstrated that kinematically aligned TKA yields improved knee range of motion and better clinical outcomes at 2 years[14]. There has been limited literature to support the use of the pre-arthritic alignment angle to optimize functional outcomes following unicompartmental knee arthroplasty (UKA). In order to determine the validity of a kinematic alignment technique for use in UKA, it is important to determine if superior outcomes can be achieved in knees whose postoperative alignment falls within their pre-arthritic alignment angle compared with knees outside of this range.

The purpose of the present study was to determine if operative restoration of the kinematic alignment (i.e., the constitutional alignment) of the knee following non-robotically assisted, fixed-bearing medial UKA would result in sustained long-term restoration of function and return to activity without conversion to TKA. We hypothesized that pre-arthritic/kinematically aligned knees would show significantly better results following non-robotically assisted, fixed-bearing medial UKA compared with non-pre-arthritic, kinematically aligned knees.

Materials and Methods

Data were recorded for a total of 236 knees treated with a non-robotically assisted, fixed-bearing UKA (Zimmer Unicompartmental High Flex Knee System [ZUK]; Smith & Nephew) by a single surgeon (K.D.P.) between 2000 and 2015. Selection of patients and surgical technique for UKA were performed according to the criteria proposed by Dunn et al.[15]. A kinematic-alignment surgical protocol had not been developed at the time of these cases. Patients were included in the study if they had undergone medial UKA with preoperative and postoperative 3-foot (1-m)-long standing hip-knee-ankle radiographs available. Patients were excluded if they had inadequate or poor-quality preoperative or postoperative radiographs, declined to participate, were deceased at the minimum 4-year follow-up, had undergone lateral UKA, or had a preoperative varus alignment of ≥15°. All patients with ≥15° of varus were indicated for TKA. A total of 150 patients met the inclusion criteria (Fig. 1). This study was approved by the institutional review board.

Evaluation of HKAA

Varus deformity was assessed with use of the HKAA, as measured on 3-foot (1-m)-long standing anteroposterior radiographs according to previously described methods[2,16-18] (Fig. 2-A). The HKAA is the angle of intersection of a line drawn from the center of the femoral head through the center of the femoral condyles and a line drawn from the center of the talus through the center of the tibial spines[16,17].

Determination of Pre-Arthritic/Kinematic Alignment

The arithmetic HKAA (aHKA) was utilized to estimate pre-arthritic/kinematic alignment[18,19]. All measurements were obtained retrospectively on preoperative standardized 3-foot (1-m)-long standing anteroposterior radiographs. The lateral distal femoral angle was measured as the lateral angle formed by the mechanical axis of the femur and a line drawn across the articular surface of the distal femur at the most distal points of the lateral and medial femoral condyles (Fig. 2-B). The medial proximal tibial angle was measured as the angle formed medially by the mechanical axis of the tibia and a line drawn between the most distal articular contours of the midpoints of the lateral and medial plateaus (Fig. 2-C). The aHKA (pre-arthritic angle) was calculated by subtracting the lateral distal femoral angle from the medial proximal tibial angle[18,19]. A patient was considered to have pre-arthritic/kinematic alignment if their postoperative HKAA was within 1 standard deviation (±3°) of their aHKA, as previously described in the literature[18,19]. All radiographic measurements were performed by an independent examiner. Interobserver and intraobserver agreement for aHKA and HKAA has been previously reported to be 0.95 or higher, indicating excellent agreement[18].

Knees were divided into 2 cohorts according to whether or not the patient had pre-arthritic kinematic alignment following UKA.

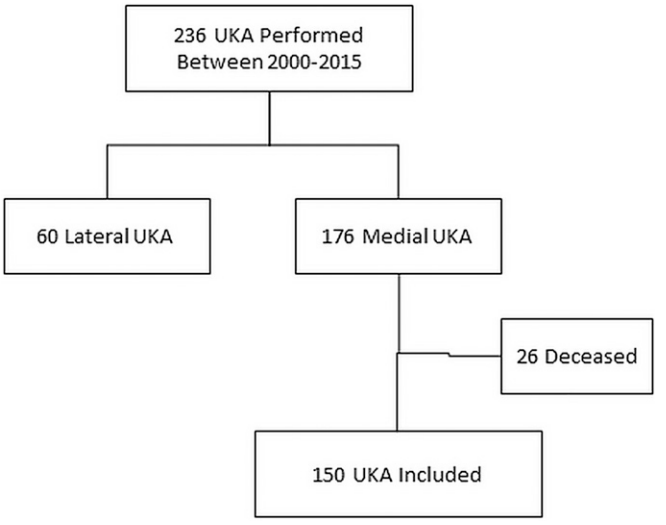


Fig. 1
Flow chart showing patient cohort inclusion.

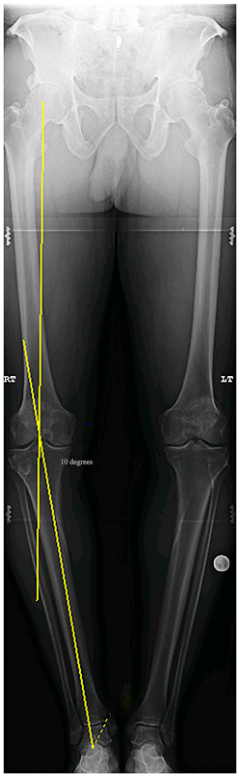
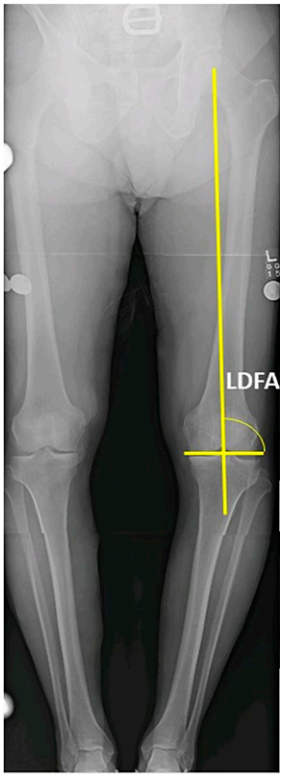


Fig. 2-A



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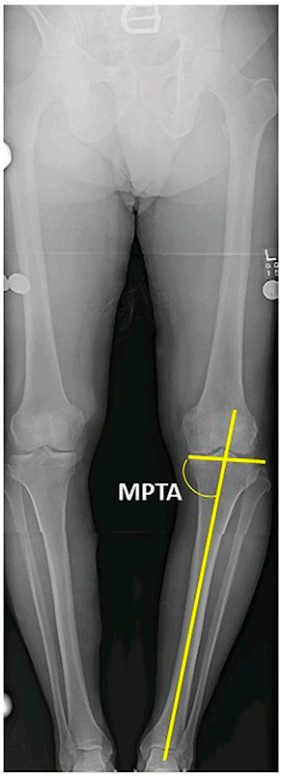

Fig. 2-C

Fig. 2-A Three-foot (1-m)-long standing anteroposterior radiograph showing the HKAA. This angle was defined as the angle of intersection of a line drawn from the center of the femoral head through the center of the femoral condyles and a line drawn from the center of the talus through the center of the tibial spines. The angle shown in this radiograph is 10°. **Fig. 2-B** Three-foot (1-m)-long standing anteroposterior radiograph showing the lateral distal femoral angle (LDFA). This angle was defined as the lateral angle formed by the mechanical axis of the femur and a line drawn across the articular surface of the distal femur at the most distal points of the lateral and medial femoral condyles. **Fig. 2-C** Three-foot (1-m)-long standing anteroposterior radiograph showing the medial posterior tibial angle (MPTA). This angle was defined as the angle formed medially by the mechanical axis of the tibia and a line drawn between the most distal articular contours of the midpoints of the lateral and medial plateaus.

Outcome Reporting

Patient-reported outcomes and clinical findings were collected postoperatively at the time of the latest follow-up. Findings from clinical examinations included knee flexion and extension range of motion. The primary activity outcomes were the Knee Injury and Osteoarthritis Outcome Score (KOOS) Activities of Daily Living and Sport subscales, including the percentage of patients who reached the patient acceptable symptom state (PASS)[20-22]. Secondary outcomes included the Veterans RAND (VR)-12 Physical Component Summary Score and Mental Component Summary Score; the KOOS Pain, Symptoms, and Quality of Life subscales; and the Lysholm score. The previously reported PASS values for the KOOS subscales include 87.5 for Activities of Daily Living, 43.8 for Sport, 87.0 for Pain, 84.0 for Symptoms, and 66 for Quality of Life in patients undergoing TKA[20]. The previously reported PASS for the Lysholm score is 70 in patients undergoing cartilage-repair procedures[23]. All patients completed questionnaires independently.

Statistics

Data were summarized as means with standard deviation or ranges. Variables were tested for normal distribution with use of the Kolmogorov-Smirnov test. Nonparametric univariate analyses were performed with use of the Mann-Whitney U test for 2-group comparisons and the Spearman rho for correlations when values demonstrated a significant departure from the normal distribution. Chi square was used for comparison of binary categorical variables. All p values were 2-tailed. Significance was set at 0.05. The end point for survivorship was TKA. The Kaplan-Meier method was utilized to determine survivorship of the prosthesis. Equality of survival between kinematically aligned knees and non-kinematically aligned knees was determined with use of the log rank (Mantel-Cox) test. Statistical analysis was performed with use of SPSS (version 11.0; SPSS).

Source of Funding

There was no external funding for this study.

Results

A total of 236 UKAs were performed from 2000 to 2015. Of these, a total of 150 medial UKAs (76 female and 74 male) met the inclusion criteria and were included in the study. The mean age was 65 ± 10 years and the mean body mass index (BMI) was 28.6 ± 5 kg/m^2 (Fig. 1). There were no postoperative

TABLE I Patient Demographics for the Pre-Arthritic/Kinematically Aligned and Non-Pre-Arthritic/Kinematically Aligned Cohorts*

	Pre-Arthritic/Kinematically Aligned (N = 127)	Non-Pre-Arthritic/Kinematically Aligned (N = 23)	P Value
Age *(yr)*	65 ± 10	65 ± 9	0.956
BMI *(kg/m²)*	28.3 ± 5	29.7 ± 6	0.317
Sex, female:male	64:63	12:11	0.875
Preoperative HKAA	5.9° ± 3°	6.9° ± 3°	0.205
Postoperative HKAA	4.2° ± 3°	5.8° ± 5°	0.158
Medial proximal tibial angle	85° ± 3°	83° ± 3°	0.098
Lateral distal femoral angle	89° ± 2°	89° ± 2°	0.913
aHKA	3.72° ± 3°	5° ± 3.6°	0.109

*Values are given as the mean ± standard deviation, unless noted. Age was compared between cohorts with use of an independent t test; all other variables were compared with use of the Mann-Whitney U test for a nonparametric distribution.

infections in the operative knees, as defined according to the Centers for Disease Control and Prevention guidelines[24]. The average preoperative HKAA was 6° ± 3.5°. A total of 127 knees (85%) were pre-arthritic/kinematically aligned, and 23 knees (15%) were to be non-pre-arthritic/kinematically aligned. Patient demographics for the pre-arthritic/kinematically aligned and non-pre-arthritic/kinematically aligned cohorts are presented in Table I.

Five knees (3%) in 4 patients were converted to TKA (Table II), including 3 knees in 3 patients that sustained early failure as a result of technical errors within 2.5 years. These knees were noted to be outside the pre-arthritic/kinematically aligned range. The remaining 2 knees required conversion to TKA as a result of a traumatic injury. The mean survival time estimate was 18.3 years (95% confidence interval [CI], 17.8 to 18.8) in all patients. Mean survival of the pre-arthritic/kinematically aligned cohort was 18.6 years (95% CI, 18.2 to 19) compared with 15.4 years (95% CI, 13.4 to 17.5) in the non-pre-arthritic, kinematically aligned cohort (p = 0.008). The Kaplan-Meier survival curves are shown in Figure 3. At 10 years, the survivorship was 97% (95% CI, 93% to 100%) for the pre-arthritic/kinematically aligned cohort and 87% (95% CI, 73% to 100%) for the non-pre-arthritic/kinematically-aligned cohort.

At average 10-year follow-up (range, 4 to 20 years), the pre-arthritic/kinematically aligned cohort had significantly higher KOOS Activities of Daily Living (92) and KOOS Sport (74) scores compared with the non-pre-arthritic, kinematically aligned cohort (74, p < 0.001, and 36, p < 0.001, respectively) (Table III). In addition, Lysholm, KOOS Quality of Life, and KOOS Pain were significantly higher in the pre-arthritic/kinematically aligned cohort (p < 0.05).

The pre-arthritic/kinematically aligned cohort had a significantly greater proportion of patients meet the PASS for KOOS Activities of Daily Living (85%) and KOOS Sport (87%) compared with the non-pre-arthritic, kinematically aligned cohort (28%, p < 0.01, and 57%, p < 0.01, respectively) (Fig. 4). The PASS for the Lysholm was achieved in 86% of patients in the pre-arthritic/kinematically aligned cohort compared with 48% in the non-pre-arthritic, kinematically aligned cohort (p < 0.01).

Data for knee range of motion at the time of the latest follow-up are shown in Table IV. In the pre-arthritic/kinematically aligned cohort, 2% of knees (n = 2) had a loss of extension of >5° compared with 9% of knees (n = 2) in the non-pre-arthritic, kinematically aligned cohort (p = 0.004). Postoperative knee flexion range of motion was not significantly different between the pre-arthritic/kinematically aligned cohort (130 ± 9°) and the non-pre-arthritic, kinematically aligned cohort (126° ± 9°, p = 0.098).

TABLE II Details of the 5 Knees That Required Conversion to TKA

Patient	Age at Index UKA *(yr)*	Years to TKA Conversion	Sex	BMI *(kg/m²)*	Reason for Failure	Preoperative HKAA	Postoperative HKAA*	aHKA
1	60	2	F	40.7	Technical error	5°	−2°	2°
2	63	2.5	F	23.4	Technical error	4°	−1°	3°
3	68	2	F	28.7	Technical error	2°	0°	4°
4	59	9	F	40	Trauma	4°	4°	3°
5	74	10.5	F	19	Trauma	2°	2°	3°

*Negative value indicates valgus alignment.

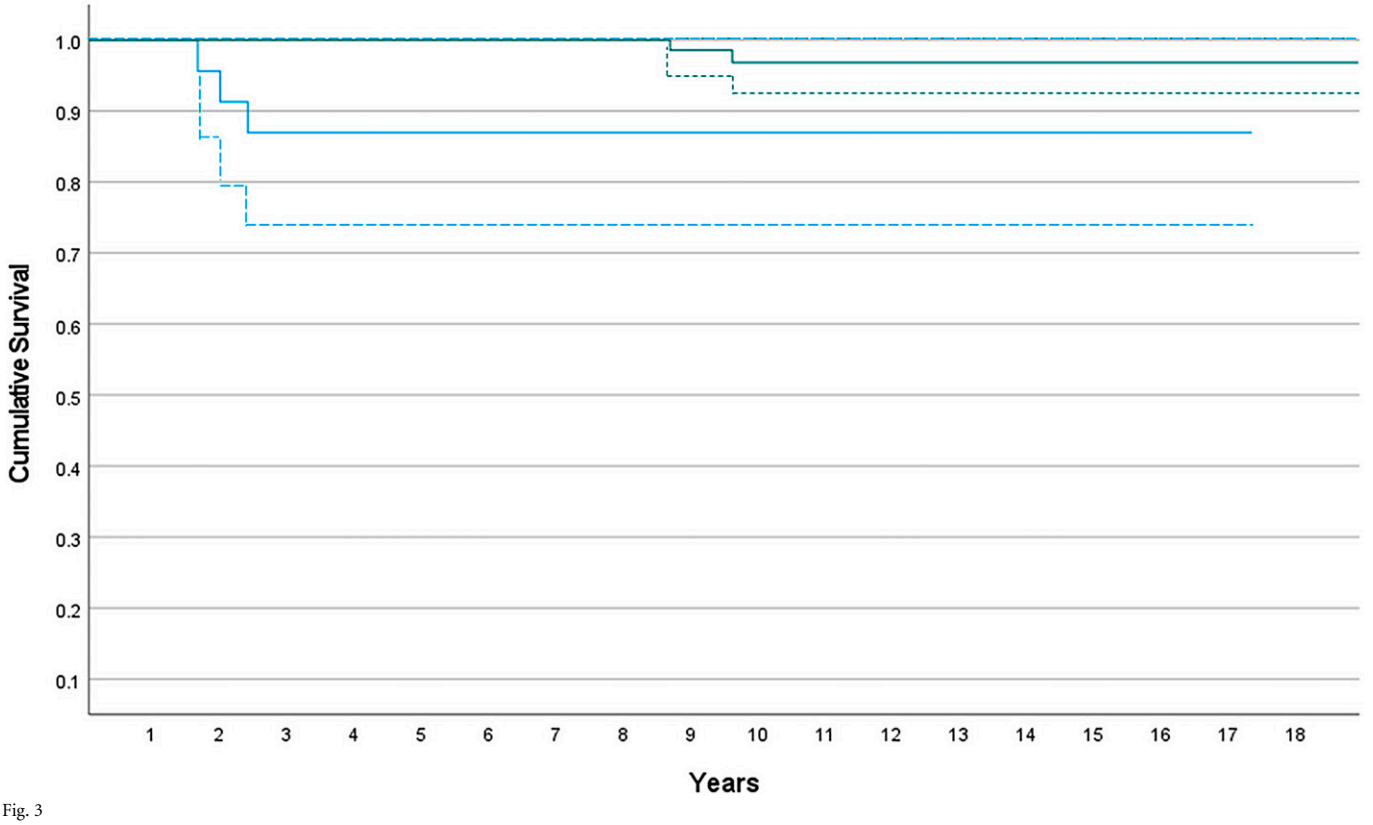

Fig. 3

Kaplan-Meier survival curves (and 95% CIs) with conversion to TKA as the end point. The pre-arthritic/kinematically aligned cohort is dark green and the non-pre-arthritic/kinematically aligned cohort is light blue. Dotted lines represent the 95% confidence intervals.

No knees had anterior-posterior or medial-lateral instability in mid-flexion at the time of the latest follow-up.

Discussion

Pre-arthritic/kinematic alignment has been suggested to yield superior results compared with mechanical alignment following TKA[9-13]. Mechanical alignment has been used as a standard technique when performing UKA, no different from TKA. Analysis of many worldwide registries revealed limited survivorship beyond 7 years for UKA[25]. This lack of survival for a UKA prothesis is concerning, especially when compared with the successful long-term results of TKA. It is necessary to identify factors to improve patient outcomes

TABLE III Postoperative Patient-Reported Outcome Scores*

	Pre-Arthritic/Kinematically Aligned Cohort (N = 127)	Non-Pre-Arthritic/Kinematically Aligned Cohort (N = 23)	P Value
VR-12 MCS	54 ± 5	55 ± 5	0.442
VR-12 PCS	56 ± 8	53 ± 8	0.196
KOOS Pain	89 ± 15	75 ± 18	0.001
KOOS Symptoms	82 ± 14	68 ± 17	<0.001
KOOS ADL	92 ± 11	74 ± 17	<0.001
KOOS Sport	74 ± 27	36 ± 31	<0.001
KOOS QoL	82 ± 19	56 ± 28	0.001
Lysholm	87 ± 16	68 ± 23	0.003

*Values are given as the mean ± standard deviation. All variables were compared with use of the Mann-Whitney U Test for a nonparametric distribution. MCS = Mental Component Summary Score, PCS = Physical Component Summary Score, ADL = Activities of Daily Living, QoL = Quality of Life.

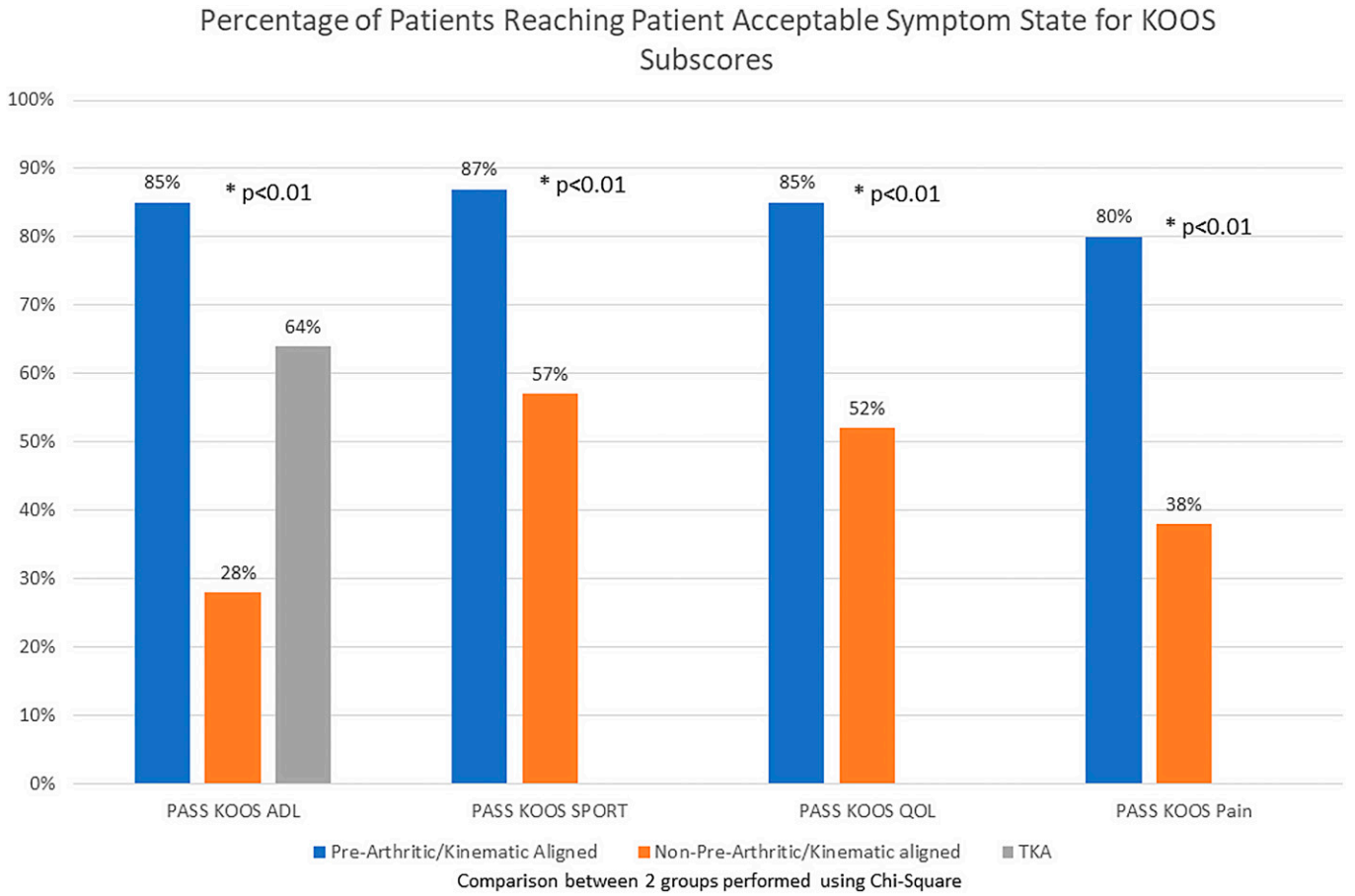

Fig. 4

Bar graph showing the proportion of patients in each cohort meeting the PASS for each KOOS subscale. For each subscale, a significantly greater proportion met the PASS in the pre-arthritic/kinematically aligned cohort ($p < 0.01$). Following TKA, 64% of patients reached the PASS for KOOS Activities of Daily Living (ADL).[31] Following cartilage repair, 46% of patients reached the PASS for KOOS ADL, 62% for KOOS Sport, 65% for KOOS Symptoms, 71% for KOOS Pain, and 50% for KOOS quality of life (QOL)[23].

and increase implant survival following UKA. In the present study, we investigated whether use of the pre-arthritic alignment angle would lead to favorable outcomes following UKA. Because of the general lack of agreement in the literature regarding the optimal postoperative alignment strategy in UKA, we retrospectively assessed patient data to find the pre-arthritic/kinematic alignment angle, as measured on 3-foot (1-m)-long standing radiographs with use of a simple arithmetic method[26,27]. We then assessed whether knees that had postoperative alignment within 3° of their pre-arthritic alignment showed superior results compared with knees that had

TABLE IV Preoperative and Postoperative Range of Motion*

	Pre-Arthritic/Kinematically Aligned Cohort (N = 127)	Non-Pre-Arthritic/Kinematically Aligned Cohort (N = 23)	P Value
Preoperative extension	2.4° (0° to 15°)	3.45° (0° to 25°)	0.771
Postoperative extension	0.47° (−1° to 15°)	0.75° (−1° to 7°)	0.812
Preoperative flexion	121° (90° to 145°)	118° (95° to 140°)	0.033
Postoperative flexion	130° (100° to 150°)	126° (100° to 135°)	0.098

*The values are given as the mean, with the range in parentheses. All variables were compared with use of the Mann-Whitney U test for a nonparametric distribution. For comparison, the mean postoperative range of motion following TKA was reported to be between 104° and 128° in a recent meta-analysis[38].

postoperative alignment outside this range. The present study demonstrated significantly higher patient-reported outcomes at a mean of 10 years and superior longevity (mean survivorship, 19 years) among patients with versus without a postoperative knee alignment ≤3° from their pre-arthritic angle. In addition, a greater proportion of these patients met the PASS for KOOS Activities of Daily Living and Sport.

Normal alignment of the lower extremity is considered 2° to 3° of varus; however, deviation from this range is not uncommon[2]. In a cohort of 250 healthy, asymptomatic knees, Bellemans et al. reported that 32% of those in men and 17% of those in women had a mechanical alignment with >3° of varus[2]. The authors suggested that restoration of neutral alignment in TKA may be undesirable and could explain the unacceptably high rate of dissatisfaction following TKA observed in some studies[2]. Similar to Bellemans et al., the present cohort had a wide distribution of alignment, from neutral to marked varus. In patients whose pre-arthritic alignment falls outside of the normal 2° to 3° of varus, there are concerns of correcting to neutral as this may potentially increase loading on the medial proximal tibial cortex and lead to an increased risk of early failure[28,29].

The present results support the use of pre-arthritic kinematic alignment in patients undergoing non-robotically assisted fixed-bearing medial UKA. We observed greater long-term survivorship in knees that had a postoperative alignment within 3° of their pre-arthritic kinematic alignment (19 years) compared with those outside of that range (15 years), as well as a greater proportion of patients reaching the PASS for KOOS Activities of Daily Living and Sport subscales. The greatest contributors to pre-arthritic kinematic alignment are the medial proximal tibial angle and lateral distal femoral angle[2,18]. These 2 angles can be easily measured on preoperative radiographs to estimate the pre-arthritic alignment. This method has been well described by MacDessi et al., who defined pre-arthritic kinematic alignment in candidates for TKA with Kellgren-Lawrence grade 3 or 4 tibiofemoral osteoarthritis[18]. With use of these methods, we retrospectively calculated the pre-arthritic/kinematic alignment and measured the postoperative alignment in individual patients and compared the values to determine whether the knee was kinematically aligned postoperatively.

The optimal alignment following UKA has been heavily debated in the literature. Kleeblad et al. investigated the effect of large varus deformities on postoperative alignment[3]. The authors defined the optimal postoperative alignment as ≤4° of varus, and acceptable alignment as 5° to 7° of varus[3]. Hernigou and Deschamps demonstrated the importance of postoperative alignment in medial UKA[30]. In their series of 58 knees with a mean follow-up of 15 years, the authors found that postoperative alignment of >7° of varus, or under correction, increased the risk of early polyethylene wear and aseptic loosening. Overcorrection was associated with increased risk of osteoarthritis in the lateral compartment, whereas, severe under correction (i.e., >10° of varus) was associated with increased tibial component wear. Conversely, Zuiderbaan et al. reported no revisions at a mean of 2.3 years in a consecutive series of 104 patients who underwent medial UKA[5]. In that study, 25% of patients had a preoperative HKAA of 10° to 15° of varus, and 32% had a postoperative HKAA of >4° of varus[5]. Large varus deformities of >10° and <15° were not found to be a contraindication for UKA in that study, and no patient with these large varus deformities underwent conversion to TKA.

Superior KOOS Activities of Daily Living and Sport subscores were observed among knees that were within 3° of their pre-arthritic/kinematic alignment, with a greater proportion meeting the PASS for these measures. In a previous study, Connelly et al. reported that only 64% of patients who underwent TKA[31] and 46% of patients who underwent cartilage repair[23] met the PASS for KOOS Activities of Daily Living, compared with 85% of the patients with pre-arthritic/kinematically aligned UKAs in the present study[31]. Chahal et al. also reported that only 62% of patients met the PASS for KOOS Sport and 50% met the PASS for KOOS Quality of Life following cartilage repair compared with 77% and 80% among patients with pre-arthritic/kinematically aligned UKAs in the present study[23].

As a result of improved biomechanics, kinematic alignment has been associated with appropriate ligament tensioning and a more comfortable gait[2], which may have contributed to the greater proportion of patients who met the PASS for KOOS Sport in the pre-arthritic/kinematically aligned cohort (87%) compared with the non-pre-arthritic/kinematically aligned cohort (57%) at a mean of 10 years postoperatively. KOOS Sport evaluates the degree of difficulty performing squatting, running, jumping, twisting, pivoting, and kneeling. These activities have been reported by some authors to be difficult following TKA and cartilage-repair procedures[32-34]. A recent study reported a mean KOOS Sport score of only 57.5 at 5 years postoperatively among patients who underwent a cartilage-repair procedure[35]. In the present study, patients with a pre-arthritic/kinematically aligned UKA had a mean KOOS Sport score of 74 at 10 years. Physical activity level, as demonstrated by the high KOOS scores, was preserved in our cohort of patients after UKA. Maintenance of physical activity offers the well-documented benefits of psychological well-being, social mobility, and reduced risk of comorbidities including obesity, hypertension, cardiovascular disease, diabetes, and osteoporosis, especially in the aging population[36].

The strengths of the present study included the duration of follow-up, inclusion of both subjective and objective outcome measures, high internal validity with our single-surgeon design, and the use of plain 3-foot (1-m)-long standing radiographs. However, this study had limitations. The study was based on the experience of a single physician, therefore limiting the generalizability of the results to other centers or surgeons. However, the single-surgeon study shows the applicability of the results to medium-volume surgeons, who represent the majority of orthopaedic surgeons performing this procedure[37]. Another limitation was that the study did not compare kinematic alignment with other alignment targets. Only 14% of our patients had large varus deformities. This limited number of patients was partially a result

of the algorithm utilized by the senior author to determine patient fit for TKA, in which only knees with large deformities (≥15°) were indicated for the procedure. Given the retrospective design of this study, future research should prospectively study the use of the aHKA, its applicability in preoperative planning for UKA, and its accuracy in achieving the target kinematic alignment. Restoration of kinematic alignment in patients with larger preoperative varus deformities should also be evaluated. Nonetheless, this cohort demonstrated reproducible, excellent results with a very low revision rate at 10 years and a mean survivorship of 18.3 years.

Conclusions

In this study, knees that had a postoperative alignment that was within 3° of their preoperative, pre-arthritic/kinematic alignment showed superior prosthesis longevity and return to activity following medial UKA. The low rate of conversion to TKA and the excellent outcomes in these knees support the use of kinematic alignment in UKA. Knees with a postoperative pre-arthritic/kinematic alignment had mean survivorship was 19 years and significantly higher KOOS Activities of Daily Living (PASS, 85%) and Sport (PASS, 87%) at a mean of 10 years compared with those without a postoperative pre-arthritic/kinematic alignment. We encourage surgeons performing UKA to utilize calculation of the aHKA on 3-foot (1-m)-long standing radiographs, as has been described for TKA, in order to identify the pre-arthritic/kinematic alignment in patients with isolated medial compartment osteoarthritis to achieve similar outcomes. ■

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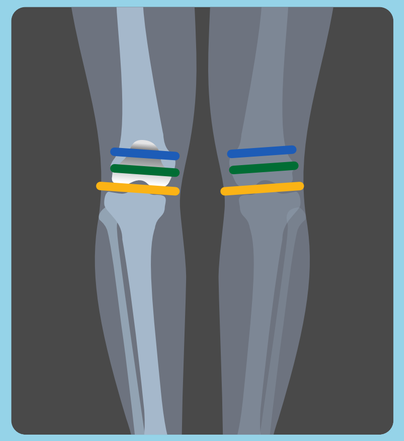
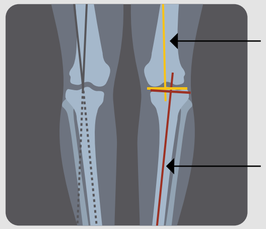
Pre-Arthritic/Kinematic Alignment in Unicompartmental Knee Arthroplasty Restores Activity

In patients undergoing unicompartmental knee arthroplasty (UKA), could pre-arthritic/kinematic alignment help restore long-term function?



150 patients who underwent UKA during 2000–2015

- **n = 127** with pre-arthritic/kinematic alignment
- **n = 23** with non-pre-arthritic/kinematic alignment



Pre-arthritic/kinematic alignment estimated using arithmetic hip-knee-ankle angle (aHKA = MPTA – LDFA)

Mean follow-up of 10 years

MPTA: medial proximal tibial angle | LDFA: lateral distal femoral angle

Outcomes after 10 years

Outcome measures	Pre-arthritic/kinematic alignment	Non-pre-arthritic/kinematic alignment	*p*-value
Mean survival time (years)	18.6 (95% CI, 18.2–19)	15.4 (95% CI, 13.4–17.5)	$p = 0.008$
KOOS Activities of Daily Living	92	74	$p < 0.001$
KOOS Sport	74	36	$p < 0.001$
Proportion of knees achieving PASS for KOOS Activities of Daily Living	85%	28%	$p < 0.01$
Proportion of knees achieving PASS for KOOS Sport	87%	57%	$p < 0.01$

KOOS: Knee Injury and Osteoarthritis Outcome Score | PASS: patient acceptable symptom state

Restoration of pre-arthritic/kinematic alignment of knees yields significantly better functional outcomes and return to activities than non-pre-arthritic/kinematic alignment at an average of 10 years after UKA

Pre-Arthritic/Kinematic Alignment in Fixed-Bearing Medial Unicompartmental Knee Arthroplasty Results in Return to Activity at Mean 10-Year Follow-up

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