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Predicting the Feasibility of Correcting Mechanical Axis in Large Varus Deformities With Unicompartmental Knee Arthroplasty

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ABSTRACT

Background: Due to disappointing historical outcomes of unicompartmental knee arthroplasty (UKA), Kozinn and Scott proposed strict selection criteria, including preoperative varus alignment of ≤15°, to improve the outcomes of UKA. No studies to date, however, have assessed the feasibility of correcting large preoperative varus deformities with UKA surgery. The study goals were therefore to (1) assess to what extent patients with large varus deformities could be corrected and (2) determine radiographic parameters to predict sufficient correction.

Methods: In 200 consecutive robotic-arm assisted medial UKA patients with large preoperative varus deformities (≥7°), the mechanical axis angle (MAA) and joint line convergence angle (JLCA) were measured on hip-knee-ankle radiographs. It was assessed what number of patients were corrected to optimal (≤4°) and acceptable (5°-7°) alignment, and whether the feasibility of this correction could be predicted using an estimated MAA (eMAA, preoperative MAA−JLCA) using regression analyses.

Results: Mean preoperative MAA was 10° of varus (range, 7°-18°), JLCA was 5° (1°-12°), postoperative MAA was 4° of varus (−3° to 8°), and correction was 6° (1°-14°). Postoperative optimal alignment was achieved in 62% and acceptable alignment in 36%. The eMAA was a significant predictor for optimal postoperative alignment, when corrected for age and gender ($P < .001$).

Conclusion: Patients with large preoperative varus deformities (7°-18°) could be considered candidates for medial UKA, as 98% was corrected to optimal or acceptable alignment, although cautious approach is needed in deformities >15°. Furthermore, it was noted that the feasibility of achieving optimal alignment could be predicted using the preoperative MAA, JLCA, and age.

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Unicompartmental knee arthroplasty (UKA) has proven to be an effective treatment for isolated medial compartment knee osteoarthritis in appropriate selected patients [1]. Historically, however, outcomes of UKA were disappointing and, as a result, Kozinn and Scott [2] proposed strict selection criteria in their landmark paper in 1989. One of the criteria was that medial UKA should only be performed in patients with a preoperative varus deformity of 15° or less that is correctable to neutral [2]. This is based on the rationale that it is less feasible to restore the mechanical axis angle (MAA) to neutral or close to neutral in patients who have not fulfilled these criteria. A consequence of excessive residual varus alignment is increased compartment forces by overloading medially, which can ultimately lead to UKA failure from polyethylene wear or aseptic loosening [3–9].

It would be important to develop radiographic predictors of deformity correction after UKA, especially because several studies have shown that better outcomes were found in patients with a postoperative MAA of ≤7° of varus [4,10,11]. More specifically, recent studies showed that postoperative varus alignment between 1° and 4° was associated with the most

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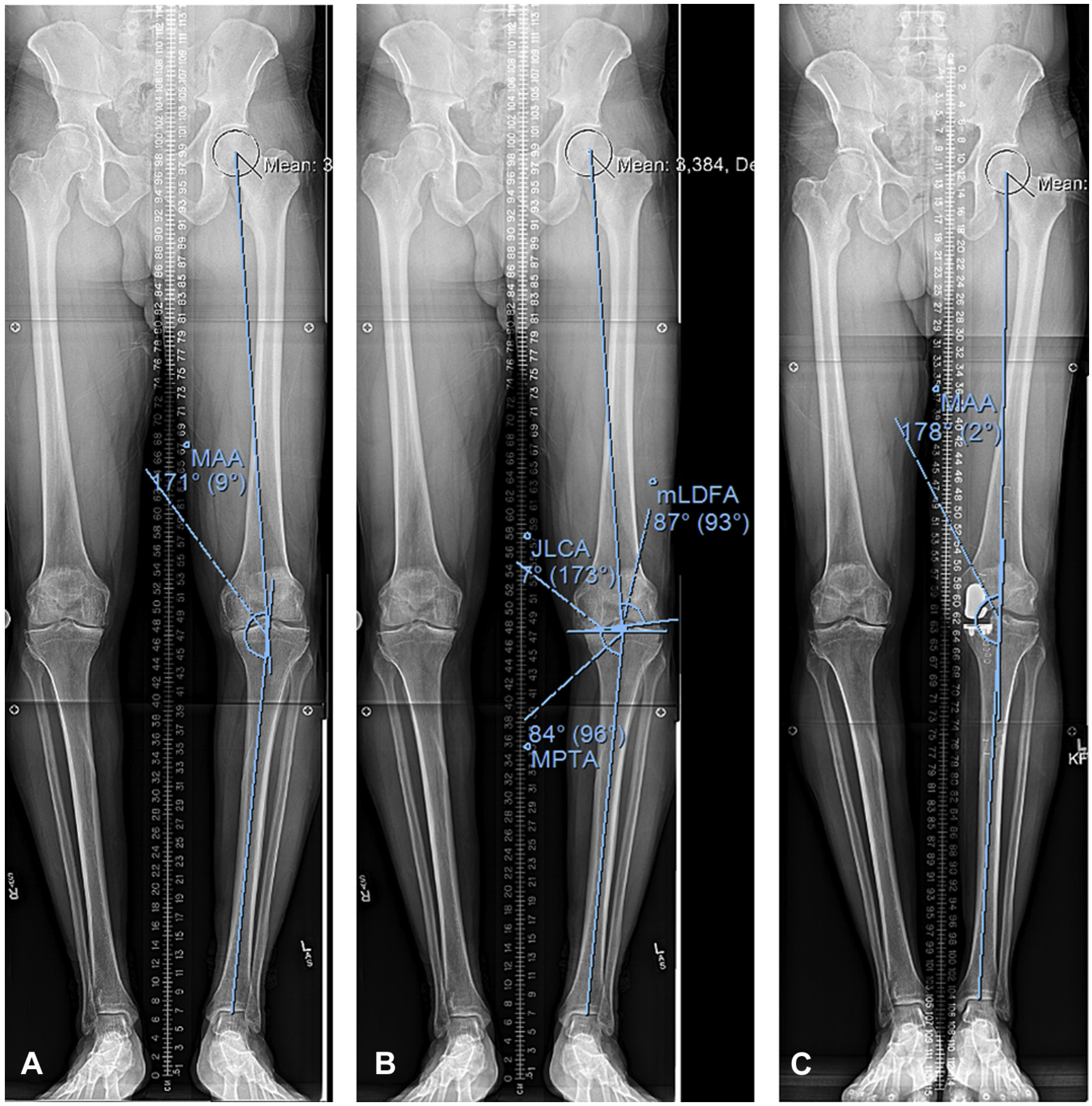

Fig. 1. Example of the radiographic assessment of the (a) preoperative mechanical axis angle (MAA), (b) mechanical lateral distal femoral angle (mLFDA), medial proximal tibial angle (MPTA), joint line convergence angle (JLCA), and (c) the postoperative MAA. These hip-knee-ankle radiographs show a preoperative MAA of 9° of varus, mLFDA of 87°, MPTA of 84°, JLCA of 7°, displaying an eMAA of 2°, which matches the postoperative MAA of 2° of varus.

optimal functional outcomes after medial UKA [6,12]. The correctability of the preoperative MAA depends on multiple factors, including the existence of femoral deformity, tibial plateau depression, and joint line convergence due to lateral collateral ligament laxity and medial compartment cartilage loss [13]. In current literature, however, there is a discrepancy to which extent large varus deformities are correctable with medial UKA surgery. Some authors suggested that most patients with a preoperative MAA of ≥10° of varus could not be corrected to neutral, indicating that patients with large preoperative varus deformities might be at risk of undercorrection [14,15]. Therefore, it could be argued that medial UKA might not be the ideal treatment option for patients with large varus deformities. On the other hand, in patients with isolated medial compartment knee osteoarthritis, the varus alignment originates mostly from a progressing intra-articular deformity [16–18]. There are, however, patients with preexistent varus alignment, even before the added degenerative intra-articular deformity. A concern may be that after correction of the articular deformity with UKA, varus alignment would still remain [19]. Chatellard et al showed that correcting the joint line obliquity through medial UKA improves the postoperative MAA and outcomes. Moreover, others emphasized that medial UKA restores the contralateral joint space width and improves joint congruence in patients with a mean preoperative varus deformity of 9° [18,20]. This implies that varus deformities can be corrected by restoring joint line obliquity during medial UKA [18,20].

Therefore, a study was performed assessing the predictive role of several radiographic deformity measurements on the postoperative mechanical axis following medial UKA in patients with large preoperative varus deformities (≥7°). The purpose of this study was 2-fold; first, determine to what extent patients with large varus deformities undergoing robotic-assisted medial UKA were correctable. Second, evaluate the predictive value of an estimated MAA (eMAA) based on the preoperative radiographic deformity measurements, in particular the preoperative MAA and joint line obliquity.

Materials and Methods

Study Design and Patient Selection

After institutional review board approval, an electronic registry search was performed using a prospective database which contains over 800 medial onlay UKAs, all performed by the senior author (ADP). Surgical inclusion criteria consisted of isolated medial osteoarthritis as primary indication, intact cruciate ligaments, passively correctable varus deformity, and less than 10° fixed flexion deformity. Surgical exclusion criterion was inflammatory arthritis. Study inclusion criteria were patients with a preoperative MAA of ≥7° of varus who had preoperative and postoperative hip-knee-ankle (HKA) radiographs. Exclusion criteria consisted of ipsilateral total hip arthroplasty (THA) or total ankle arthroplasty (TAA), or a history of lower extremity fracture. The goal was to include 200 consecutive patients who matched these criteria, as this was considered a representative group. A total of 499 patients were screened between November 2008 and November 2013, of which 245 were excluded for preoperative MAA<7°, 44 for lack of preoperative and/or postoperative HKA radiographs, 9 for ipsilateral THA or TAA, and 1 for a history of lower extremity fractures.

The postoperative alignment was categorized as optimal (≤4° of varus), acceptable (5°-7° of varus), and undercorrected (>7° of varus), which is commonly used in recent literature [4,6,10–12].

Implant and Surgical Technique

All surgeries were performed by one surgeon (ADP) and carried out using a robotic-arm assisted surgical platform (MAKO System, Stryker, Mahwah, NJ), as described previously [21,22]. All patients received a cemented fixed-bearing RESTORIS MCK Medial Onlay implant (Stryker, Mahwah, NJ). The surgical goal was to establish a relative undercorrection within the range of 1°-7° of varus, in order to avoid degenerative progression on the lateral compartment [11,18]. The surgeon considered a final lower limb alignment of 1°-4° to be optimal, but accepted a navigated final alignment between 5° and 7° if further correction was not possible without release of the medial collateral ligament (MCL). The MCL was carefully protected and there were no cases where an MCL release or a piecrusting of the MCL was performed.

Radiological Assessment

Radiographic evaluation was performed in a Picture Archiving and Communication System (PACS, Sectra Imtec AB, version 16, Linköping, Sweden). HKA standing radiographs were obtained as standard workup preoperatively and 6 weeks postoperatively. Patients were instructed to stand straight with both knees fully extended and evenly distribute their body weight between both limbs. The patellas were aligned with the direction of the X-ray beam. The X-ray beam was centered at the distal pole of the patella, aligning the image parallel to the tibial joint line in the frontal plane. In each HKA radiograph, the source-to-image distance was standardized to 122 cm by a standard 256 0.25-mm AISI 316 stainless steel calibration sphere (Calibration Unit; Sectra) to account for any magnification effects [23].

The radiographic assessment was performed by one assessor (LJK) according to the validated methods used by Paley et al [13,16,24,25]. Using Ortho Toolbox (PACS feature), the MAA, mechanical lateral distal femoral angle (mLDFA), medial proximal tibial angle (MPTA), and joint line convergence angle (JLCA) were determined for each patient [16,17,26]. The MAA is defined as the angle between the femoral mechanical axis (center of hip to intercondylar notch of knee) and the tibial mechanical axis (center of tibial spines to center of the distal tibia). The mLDFA is the lateral angle formed between the femoral mechanical axis and the knee joint line of the femur in the frontal plane. Defining the MPTA, the proximal medial angle formed between the tibial mechanical axis and the knee joint line of the tibia in the frontal plane. The angle formed between femoral and tibial joint orientation lines is called the JLCA [13,26]. In case of medial osteoarthritis, there is medial JLCA convergence often due to medial cartilage loss [13,17]. Postoperatively, only the MAA was determined, because the joint orientation lines were indistinctive by use of the polyethylene insert. Marx et al [24] showed good to excellent intraobserver and interobserver reliability of lower extremity alignment measurements using a corresponding method (0.97 and 0.96, respectively). The correction was defined as the change in MAA, comparing the preoperative MAA relative to the postoperative MAA. All measured angles are displayed in Figure 1.

Table 1
Demographic Characteristics.

	Mean ± SD (Range)
Age (y)	64.7 ± 10.1 (43.4-86.6)
BMI	30.4 ± 5.9 (18.6-52.9)
Gender ratio	124 men:76 women

SD, standard deviation; BMI, body mass index.

Statistical Analysis

All analyses were conducted using SPSS version 24 (SPSS Inc, Armonk, NY) and SAS version 9.3 (SAS Inc, Cary, NC). Descriptive analyses were reported using means and standard deviations (SD) for continuous variables and frequencies with percentages for discrete variables. With regard to the first research question, it was assessed to what extent patients were corrected to an optimal MAA (≤4° of varus) and acceptable MAA (5°-7° of varus), which was based on the aforementioned recent literature [4,6,10,12]. Furthermore, a subgroup analysis was performed based on the preoperative MAA to describe the distribution of postoperative alignment and JLCA. For the second research question regarding the feasibility of achieving this optimal postoperative alignment, an eMAA was calculated by subtracting the JLCA from the preoperative MAA (preoperative MAA−JCLA). The predictive value of the eMAA was tested by means of a correlation analysis and chi-square test. The role of extra-articular deformities in achieving optimal postoperative alignment was assessed using MPTA and mLDFA. Finally, a multivariable logistic regression model was fitted to examine the feasibility of achieving an optimal MAA (≤4° of varus), based on the eMAA and corrected for patient-related factors (age, gender, body mass index). A P value <.05 was considered statistically significant.

Table 2
Preoperative and Postoperative Angle Measurements According to the Method of Paley et al.

	Mean ± SD	Minimum	Maximum
Preoperative			
Mechanical axis angle (varus)	10° ± 2.3°	7°	18°
Mechanical lateral distal femur angle	89° ± 1.9°	85°	95°
Medial proximal tibial angle	84° ± 6.1°	78°	91°
Joint line convergence angle	5° ± 1.8°	1°	12°
Postoperative			
Mechanical axis angle (varus)	4° ± 2.1°	−3°	8°
Correction	6° ± 2.5°	1°	14°

SD, standard deviation.

Table 3
Descriptive Characteristics of the Distribution of Postoperative MAA in the Specific Groups Based on the Preoperative MAA.

Preoperative MAA	Mean Age (y)	Postoperative MAA		
		Optimal: ≤4° (N = 124)	Acceptable: 5°-7° (N = 72)	Undercorrection: ≥7° (N = 4)
7°-10° (N = 124)	63.8 (SD 10.1)	91 (73%)	32 (26%)	1 (1%)
11°-14° (N = 68)	66.8 (SD 10.1)	32 (47%)	34 (50%)	2 (3%)
15°-18° (N = 8)	64.6 (SD 10.2)	1 (13%)	6 (74%)	1 (13%)

MAA, mechanical axis angle (varus); SD, standard deviation.

Results

A total of 200 consecutive medial UKA patients were included, with a mean age of 64.7 years (SD, 10.1; range, 43.3-86.6), mean body mass index of 30.4 kg/m^2 (SD, 5.9; range, 18.6-52.9), and of which 124 patients (62%) were male (Table 1). The mean preoperative varus deformity was 10° (SD, 2.3; range, 7°-18°), mLDFA was 89° (SD, 1.9; range, 85°-95°), MPTA was 84° (SD, 6.1; range, 78°-91°), and JLCA was 5° (SD, 1.8; range, 1°-12°). Mean correction following medial UKA was 6° (SD, 2.5; range, 1°-14°) in this cohort of patients with a preoperative MAA ≥7° (Table 2).

Reviewing all 200 patients, it was noted that 62% reached an optimal MAA postoperatively, 36% an acceptable MAA, and only 4 patients (2%) had undercorrection (>7° of varus). In patients with a preoperative MAA of 7°-10° of varus, the deformity was corrected to an optimal alignment range in 73%, acceptable range in 26%, and undercorrected in 1%. In patients with a preoperative MAA of 11°-14° of varus, the deformity was in 47% corrected to optimal postoperative MAA, and in 50% to acceptable alignment. Of the patients with a preoperative MAA of 15°-18°, optimal MAA was achieved in 13%, acceptable in 74%, and undercorrection in 13% (Table 3 and Fig. 2).

The dispersion of JLCA within the subgroups is shown in Table 4. Of all patients with a preoperative varus deformity of 7°-10°, 47% had a medial JLCA of 1°-4° and 50% had a medial JLCA of 5°-8°. When the MAA increased to ranges of 11°-14° and 15°-18°, it was noted that most patients had a medial JLCA of 5°-8° (74% and 75%, respectively).

A significant positive correlation was noted between the eMAA (preoperative MAA−JLCA) and the postoperative MAA (0.467, $P < .001$). Furthermore, in the univariate analysis, a significantly higher percentage of patients achieved optimal alignment in the eMAA ≤4° group (78%) when compared to the eMAA >4° group (50%; $P < .001$). The odds of achieving postoperative MAA ≤4° was 3.4, which indicates that it is more likely to achieve optimal alignment when the eMAA is ≤4° compared to eMAA >4° (Table 5).

The role of extra-articular deformities in estimating optimal postoperative alignment was assessed using independent *t*-tests (Table 6). With regard to tibial deformities, patients with an eMAA ≤4° had a mean MPTA of 85.5° (range, 81°-91°), whereas patients with an eMAA >4° had a mean MPTA of 83.3° (range, 78°-89°; $P < .001$). Using the normal values of Paley et al, it was noted that patients with an eMAA >4° had an abnormal MPTA (<85°) more frequently compared to patients with eMAA ≤4° (70% vs 31%, $P < .001$). Regarding femoral deformities, patients with eMAA ≤4°

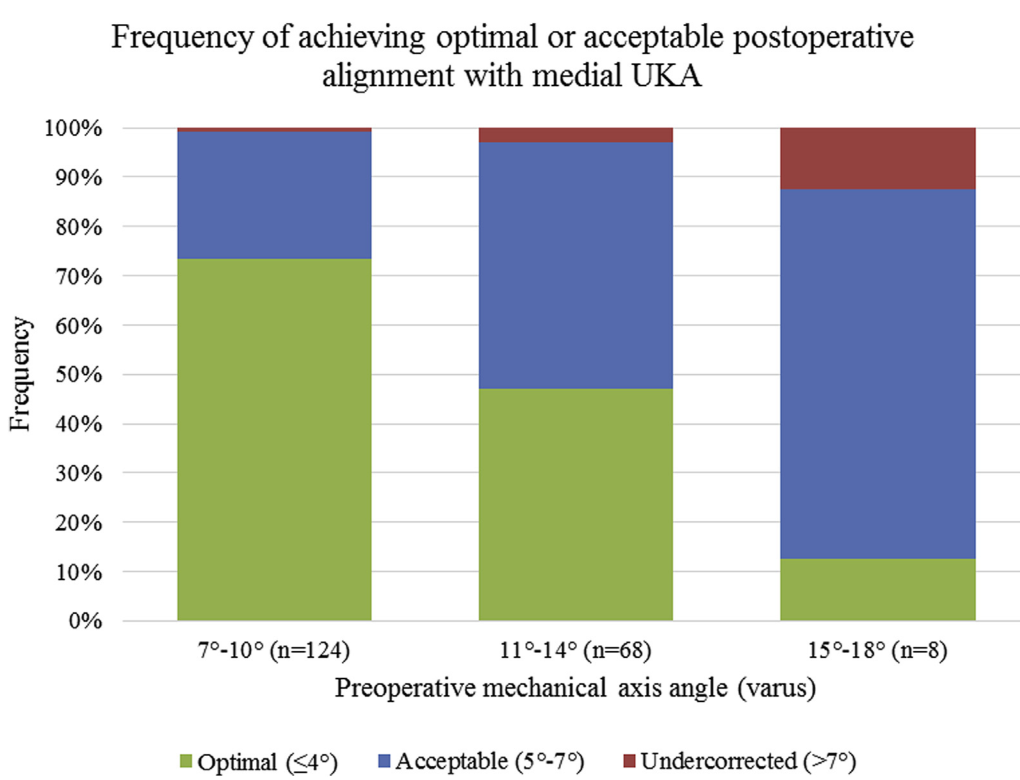

Fig. 2. Frequency of achieving optimal and acceptable postoperative varus alignment stratified by the preoperative MAA.

Table 4
Descriptive Characteristics of the Dispersion of the JLCA in the Specific Groups Based on the Preoperative MAA.

Preoperative MAA	JLCA 1°-4° (N = 74)	5°-8° (N = 118)	9°-12° (N = 8)
7°-10° (N = 124)	60 (48%)	62 (50%)	2 (2%)
11°-14° (N = 68)	14 (20%)	50 (74%)	4 (6%)
15°-18° (N = 8)	0 (0%)	6 (75%)	2 (25%)

MAA, mechanical axis angle (varus); JLCA, joint line convergence angle.

had a mean mLDFA of 88.5° (range, 85°-95°) compared to a mean mLDFA of 90.0° (range, 86°-94°) in the eMAA >4° group ($P < .001$). An abnormal mLDFA was noted in 8% of the patients with an eMAA ≤4° and in 35% of the patients with an eMAA >4° ($P < .001$).

Using a logistic regression model, the correctability of large varus deformities to a postoperative MAA ≤4° was assessed by using the eMAA ≤4°, age, and gender. The odds of achieving an optimal postoperative MAA, when the eMAA is ≤4°, was 3.62 higher in comparison to an eMAA >4° of varus ($P < .001$) when correcting for age and gender. Similarly, age as the continuous variable of age was noted to be a significant predictor (odds ratio, 0.97; $P = .026$), indicating that the chance of achieving optimal alignment decreases with 3% with every year a patient gets older (Table 7).

As shown in Figure 3, the predicted probability of achieving postoperative varus alignment within 4° decreases when the eMAA increases. When the eMAA exceeds 6.5° of varus, the likelihood of achieving optimal alignment is less than 50% (predicted probability 0.5).

Discussion

The purposes of this study were to (1) determine to what extent patients with large varus deformities were correctable to optimal (≤4°) or acceptable alignment (5°-7°) and (2) evaluate the feasibility of optimal postoperative alignment based on the eMAA in medial UKA patients. The main findings of this study were that optimal or acceptable postoperative alignment was achieved in 98% (62% and 36%, respectively) of the patients with preoperative varus deformity of ≥7° undergoing robotic-assisted medial UKA using a technique where the MCL is carefully preserved. Secondly, the eMAA was found to be a significant predictor to evaluate the feasibility of achieving optimal postoperative alignment (≤4°).

In our cohort, 62% of the patients were corrected to optimal alignment (≤4°), and in an additional 36% acceptable alignment (5°-7°) was achieved. Based on several studies, the surgical goal in medial UKA surgery is to achieve minor varus alignment postoperative and not exceed 7° of varus [10,18,27,28]. Avoiding severe undercorrection is recommended to prevent medial compartment overload, which is associated with accelerated polyethylene wear as was shown in the subgroup analysis of Hernigou and Deschamps and several other studies [4,5,9,10]. Furthermore, many authors noticed that overloading the medial compartment increases the risk of aseptic loosening [4,10,18,29]. In the absence of malalignment, almost 70% of the load across the knee passes through the medial compartment [5,17,30]. When a varus deformity increases from 4° to 6°, the load through the medial compartment approaches 90% [30]. With the presumption that undercorrection increases the risk of early polyethylene wear and aseptic loosening, many authors have, therefore, advocated to aim for minor residual varus alignment postoperatively in medial UKA patients [6,7,10,18]. Furthermore, Vasso et al and Zuiderbaan et al noted significantly higher patient-reported outcome scores (International Knee Society and Western Ontario and McMaster Universities Osteoarthritis Index, respectively) in patients with a postoperative varus alignment ≤4° [6,12]. Taking these studies into account, it could be argued that minor varus alignment (≤4°) after medial UKA is optimal.

Subsequently, across the different subgroups it has been shown that in the vast majority of patients, optimal or acceptable alignment was achieved after robotic-assisted medial UKA. However, the frequencies of achieving optimal and acceptable alignment differed between the subgroups of 7°-10°, 11°-14°, and 15°-18° (73% and 26%, 47% and 50%, and 13% and 74%, respectively). Our results were different from those of Kreitz et al [14], as they suggested that only 7.7% of their patients with a preoperative MAA of ≥10° of varus could reach neutral or beyond based on valgus stress radiographs. Furthermore, Berger et al [31] showed that in 17% of their patients (mean preoperative MAA of 8° of varus), the surgical goal (≤5° of varus) could not be achieved. However, 2 dissimilarities should be addressed: their surgical goal was slightly different, and the use of conventional methods instead of robot assistance. Robot-assisted surgery concerning medial UKA has been proven to be more accurate and less variable when compared to computer navigation or conventional UKA [6,21,32]. Studies showed that postoperative MAA was consistent within 1°-2° of preplanned position using

Table 5
Predicted Probability of Achieving a Postoperative MAA Within 4° of Varus Based on the eMAA.

	Postoperative MAA ≤4°	>4°	Chi-Square	Odds Ratio
eMAA ≤4°	66 (78%)	19 (22%)	$P < .001$	3.4
eMAA >4°	58 (50%)	57 (50%)		

Estimated MAA: preoperative MAA−JLCA.
MAA, mechanical axis angle (varus); eMAA, estimated MAA; JLCA, joint line convergence angle.

Table 6
Role of Extra-Articular Deformities in Estimating Optimal Postoperative Varus Alignment Using Medial Proximal Tibial Angle and Mechanical Lateral Distal Femur Angle.

	Medial Proximal Tibial Angle (MPTA) Mean ± SD	Minimum	Maximum	P Value	Abnormal (<85°)
eMAA ≤4°	85.5° ± 1.9°	81°	91°	<.001	31%
eMAA >4°	83.3° ± 2.0°	78°	89°		70%
	Mechanical Lateral Distal Femoral Angle (mLDFA) Mean ± SD	**Minimum**	**Maximum**	**P Value**	**Abnormal (>90°)**
eMAA ≤4°	88.5° ± 1.8°	85°	95°	<.001	8%
eMAA >4°	90.0° ± 1.8°	86°	94°		35%

Estimated MAA: preoperative MAA−JLCA.
MAA, mechanical axis angle (varus); eMAA, estimated MAA; SD, standard deviation; JLCA, joint line convergence angle.

Table 7
Predictive Model to Assess the Likelihood of Achieving an MAA Within 4° of Varus Corrected for Gender and Age Using a Logistic Regression Model.

	Postoperative MAA ≤4° Odds Ratio	95% CI	P Value
Female gender	1.79	0.94-3.38	.075
Age	0.97	0.94-0.998	.026
eMAA ≤4°	3.62	1.90-6.90	<.001

Estimated MAA: preoperative MAA−JLCA.
MAA, mechanical axis angle (varus); eMAA, estimated MAA; CI, confidence interval; JLCA, joint line convergence angle.

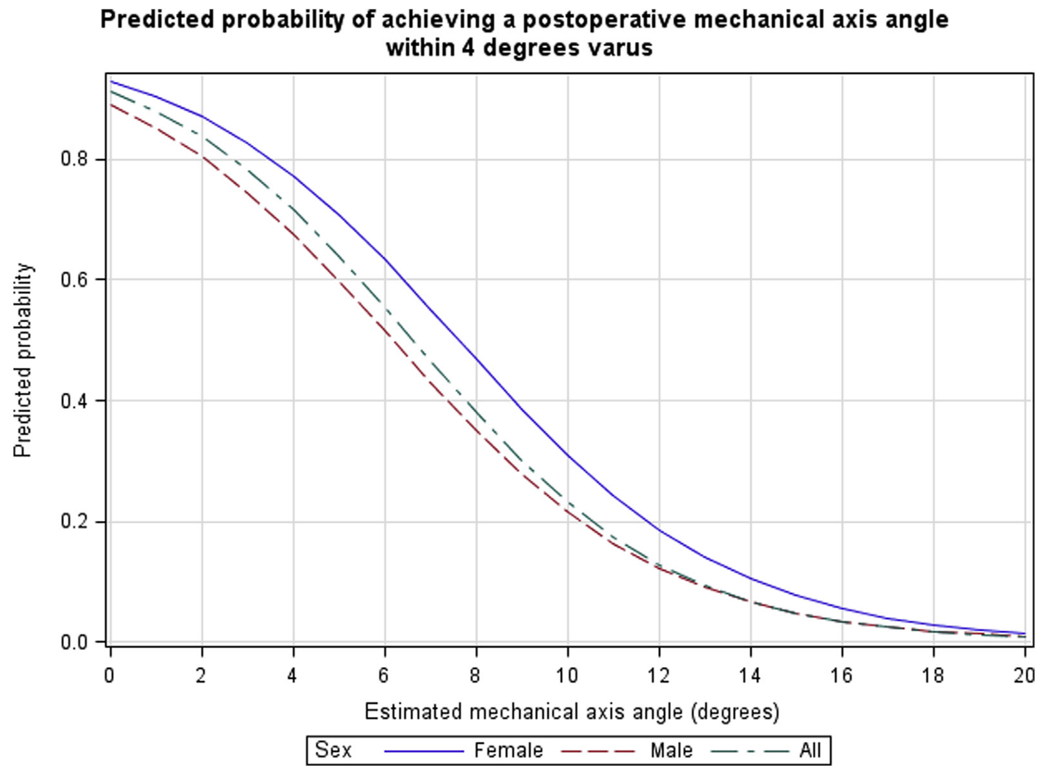

Fig. 3. Predicted probability of achieving optimal postoperative alignment with medial UKA, when correcting for age and gender using a logistic regression model.

robot assistance, a similar degree of accuracy was only achieved in 40% of conventional UKA [21,32]. Furthermore, robot-assisted surgery allows tight control, as well as improvement, of the lower leg alignment intraoperatively [33]. Therefore, the use of robot assistance might contribute favorably to the feasibility of achieving optimal or acceptable alignment during medial UKA. This study shows that 98% of the patients with large varus preoperative deformities (≥7°) were corrected within optimal or acceptable range using robot-assisted surgery.

We hypothesized that the lower limb realignment after medial UKA is driven primarily by the correction of the joint line deformity (as measured the medial JLCA) in these patients. This was based on the rationale that medial UKA restores the joint height and improves joint congruence, as was shown by Chatellard et al and Khamaisy et al [18,20]. By restoring the joint space height and congruence within the knee joint, the joint obliquity returns to neutral or close to it [13,18,20]. Using this theory, the degree of correctability of the MAA in medial UKA patients could be estimated based on the preoperative MAA and JLCA. Consequently, the eMAA (preoperative MAA−JCLA) was compared with the achieved postoperative MAA to test its predictive value. A significant correlation was found between the eMAA and the achieved postoperative MAA (0.467, P < .001). Indeed, 78% of the patients with an eMAA of ≤4° of varus achieved optimal postoperative alignment. Our results suggest that calculating an eMAA preoperatively is useful to predict the feasibility of achieving optimal postoperative alignment. When correcting for age and gender, the chance of achieving optimal postoperative alignment was 3.6 times greater when the eMAA was within similar range. Furthermore, it was noted that for every year a patient gets older, the likelihood of achieving optimal postoperative alignment decreases with 3%. This could be explained by a less compliance in the soft-tissue envelop resulting in a stiffer, less predictable correction in these knees [1,34]. Therefore, difficulty might be encountered when correcting varus deformities in the elderly.

As shown in Table 6, extra-articular deformities were more frequent in patients with an eMAA >4° compared to the eMAA ≤4° (P < .001). More specifically, the mean MPTA was within normal range in the eMAA ≤4° group, whereas the mean MPTA was outside normal range in the eMAA >4° group according to Paley et al [26,35]. In our cohort, especially more tibial deformities were observed in the eMAA >4° group compared to the eMAA ≤4° group (70% and 31%, respectively). This indicates that in patients with an eMAA >4°, the presence of extra-articular deformities using the MPTA and mLDFA should be evaluated. Moreover, when combining these findings with the significantly lower predicted probability of achieving optimal postoperative alignment (Fig. 3), other treatments, such as high tibial osteotomy and distal femoral osteotomy, may be considered in this subgroup of patients [36–39].

This study has several limitations. Firstly, there were only 8 patients included with a preoperative MAA >15°; therefore, cautious interpretation of the results of this group is necessary. Furthermore, stress views were not obtained in this study. The stress views are an established means of evaluating the flexibility of a varus deformity. However, stress views may be difficult to obtain, are operator dependent, and are non–weight-bearing. It remains unclear whether stress views are predictive of lower leg alignment correction after UKA; future studies may be directed at incorporating stress view data into realignment prediction after medial UKA. Another limitation was the use of Ortho Toolbox which permitted calibration of each HKA radiograph, but measured angles using rounded numbers. Measurements could not be taken using decimals; consequently, a standard measurement error of 0.5° has to be taken into account when interpreting the results. This method was chosen as several studies showed high reliability, and more importantly, high accuracy of this method [15,24,40,41]. Finally, the registration data concerning the intraoperative correctability and ligament tension recorded by the robotic system was not saved and therefore could not be compared to the eMAA and postoperative MAA. The role of soft-tissue balancing in correcting the mechanical axis with UKA could be assessed in future studies, as a previous TKA study already suggested an extrinsic contribution to the bony deformity, such as a tight soft-tissue envelope, in patients with a varus deformity >10° [42].

In conclusion, in this study it was noted that patients with a preoperative varus deformity between 7° and 18° could be considered candidates for medial UKA as 98% was restored to either optimal (62%) or acceptable (36%) postoperative alignment. However, a cautious approach is needed in patients with a deformity exceeding 15° of varus. Furthermore, the eMAA was a significant predictor for optimal postoperative alignment with medial UKA, when correcting for age and gender. Future studies are necessary to assess the functional outcomes and revision rates in medial UKA patients with large preoperative varus deformities.

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