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SCIENTIFIC ARTICLE

Radiologists should use the hip-knee-ankle angle rather than the mechanical axis deviation to describe knee alignment

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Abstract

Objective Preoperative and postoperative coronal knee alignment is an important predictor of total knee arthroplasty (TKA) failure. Radiologists often report the mechanical axis deviation (MAD) rather than hip-knee-ankle angle (HKAA) to describe coronal knee alignment. The aim of this study is to evaluate (i) how well the MAD predicts the HKAA; (ii) if patient height and sex affect the performance of the MAD; and (iii) if the MAD could be measured faster than the HKAA.

Materials and methods Two hundred patients undergoing hip-to-ankle radiographs for TKA planning were retrospectively reviewed. The MAD and HKAA were measured using previously published methods by the Visage picture archiving and communication systems (PACS) tools. Receiver operator characteristic (ROC) curves were used to evaluate the performance of the MAD to predict HKAA by gender and height. The performance of a linear model was used to predict HKAA from MAD in a prospectively collected cohort of 40 patients. Paired *t* tests were used for the comparison of time measurement in MAD and HKAA in this cohort.

Results MAD strongly correlated with HKAA ($r = 0.99$, $p < 0.001$); however, the performance of MAD differed by height ($p = 0.005$) and sex ($p < 0.001$). There was no significant difference in the time taken to measure HKAA versus MAD ($p > 0.05$).

Conclusion HKAA should be used instead of the MAD because it is more clinically relevant and takes the same amount of time to be measured.

Keywords Knee · Osteoarthritis · Total knee arthroplasty · Alignment · Mechanical axis

Introduction

Knee osteoarthritis is common in the aging population and has been reported in as many as 12.1% of US adults aged 60 years and older [1]. Total knee arthroplasty (TKA) is commonly performed for management of knee osteoarthritis [2]. TKA is effective in improving function and pain in most patients [3, 4]. Approximately 2.2% of TKAs fail and require revision [5]. One major factor associated with arthroplasty failure is knee coronal malalignment (deviation of greater than 3° from the mechanical axis) [6]. Restoration of neutral coronal alignment allows direct transfer of weight-bearing forces through the center of the knee, thereby decreasing asymmetric loading across the implant-bearing surface [7]. Standing hip-to-ankle radiographs can be utilized to determine coronal knee alignment before and after TKA [8, 9] and to calculate the femoral resection angle, which is the angular difference between the femoral mechanical and anatomic axes (normally 3° to 7° of valgus) [10–12]. Abnormal coronal alignment after TKA is associated with increased probability of hardware failure [6].

The gold standard metric used to evaluate coronal knee alignment is the hip-knee-ankle angle (HKAA) [13]. Prior to the widespread availability of picture archiving and communication systems (PACS), the mechanical axis deviation (MAD) was measured instead of the HKAA [14, 15]. Compared to HKAA, the MAD was simpler to measure on hard film radiography and required a view box restraining wire placed across the femoral head and tibial plafond representing the mechanical axis [14, 15]. A ruler was then used to measure the distance from this axis to the center of the knee

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[14]. This manual method was subsequently modified and used in digital radiography using the measurement tools of the digital image viewer. MAD is widely reported by radiologists for knee alignment.

Shearman's model of MAD-based HKAA approximation showed excellent correlation with HKAA measure ($r^2 = 0.99$, $p < 0.05$). Shearman's model was HKAA in degrees = y (millimeters)/3 + 1; however, this model does not account for differences in patient height or sex [14]. Men are on average taller than women; therefore, the MAD for males should be larger than that for females for the same HKAA. Similarly, the MAD for taller individuals should be larger than that for shorter individuals for the same HKAA (Fig. 1). We hypothesized that Shearman's model would likely demonstrate worse performance among patients with shorter lower extremity lengths, including short individuals and women. With the advent of picture archiving and communication systems (PACS), the relative convenience of MAD measure over HKAA is questionable.

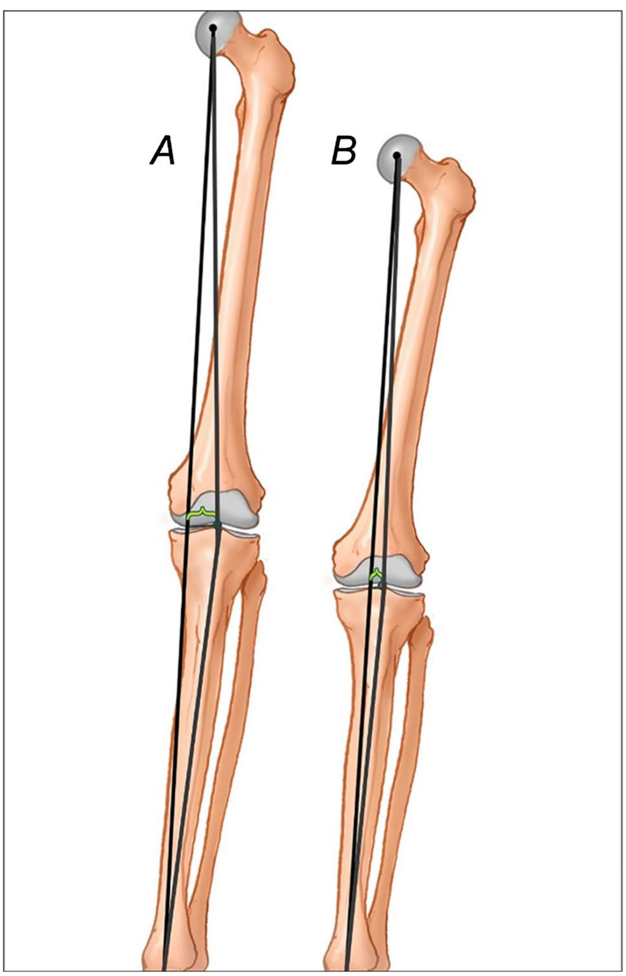

Fig. 1 Illustration showing the difference in mechanical axis deviation (MAD) with the same hip-knee-ankle angle (HKAA) in **A** taller individuals and **B** shorter individuals

The aims of our study were (i) to predict HKAA from MAD using a linear model; (ii) to determine if MAD estimation of HKAA varied by height and sex; and (iii) to evaluate whether there was any difference in time required to measure HKAA from MAD on standing hip-to-ankle radiographs using PACS.

Materials and methods

Institutional Review Board approval (#21–008,517) was obtained for this retrospective, HIPAA-compliant study. Informed consent was not required.

Patient selection

Inclusion/exclusion criteria

We conducted a retrospective review of consecutive patients undergoing hip-to-ankle radiographs from October 2020 to August 2021 as part of a clinical and/or presurgical evaluation to assess lower extremity (LE) alignment. Only patients 18 years of age and greater with radiographs of diagnostic quality and appropriate positioning were included in the study.

Discovery cohort

Radiographs from an initial study group of 200 consecutive patients (100 female, 100 male) in a model development cohort were evaluated for lower extremity length, femur length, tibia length, and intercondylar notch width.

Validation cohort

A sample size of 40 patients has 99.9% power at a type I error rate of 0.1% to detect a correlation of 0.8 (R^2 value of 0.64). Shearman et al. had an R^2 value of 0.99 from a sample size of 115 patients, so this sample size is adequately powered to detect this correlation/association. Radiographs from a randomly selected prospective validation cohort of 40 patients (20 female, 20 male) were prospectively assessed by two readers (an MSK radiology fellow and MSK faculty with 15 years' experience) for MAD and HKAA.

Radiographic technique

All radiographs were acquired via Siemens YSIO (Siemens Heathineers; Erlangen, Germany). Each patient was measured using a ruler to approximate the patient's anteroposterior thickness. This measurement of the patient's antero-posterior thickness was used to determine the appropriate dose parameters to be used by the machine. The following parameters were used for all patients: 77–85 kV; variable milliamperage; 118 in. source to image distance; four step sizes, each 14 in. × 17 in.; heels 8–10 in. apart; and no rotation. This radiograph study included both legs from the pelvis to the ankle while the patient was weight-bearing. Both lower extremities were oriented with each patella facing forward and with each knee in maximum extension. Heels were placed 8–10 in. apart. The central beam was aimed so that the beam was perpendicular to the cassette. Hip, knee, and leg radiographs were obtained separately and digitally combined using the manufacturer's software. Patients with postoperative change (e.g., arthroplasty) of the hip, knee, or ankle and patients with prior fracture with deformity of the femur, tibia, or fibula were excluded.

Radiographic measurements

All measurements were calibrated in PACS using a calibrating ball to account for radiograph magnification. Measurements of LE alignment were assessed on a Visage PACS as follows: MAD was measured by using the PACS "distance" tool to draw a straight-line axis from the center (intersection of the midline point) of the femoral head to the center of the tibial plafond and then recording the distance from this line to the center of the knee. HKAA was measured by using the PACS "angle" tool between two axes, one axis running

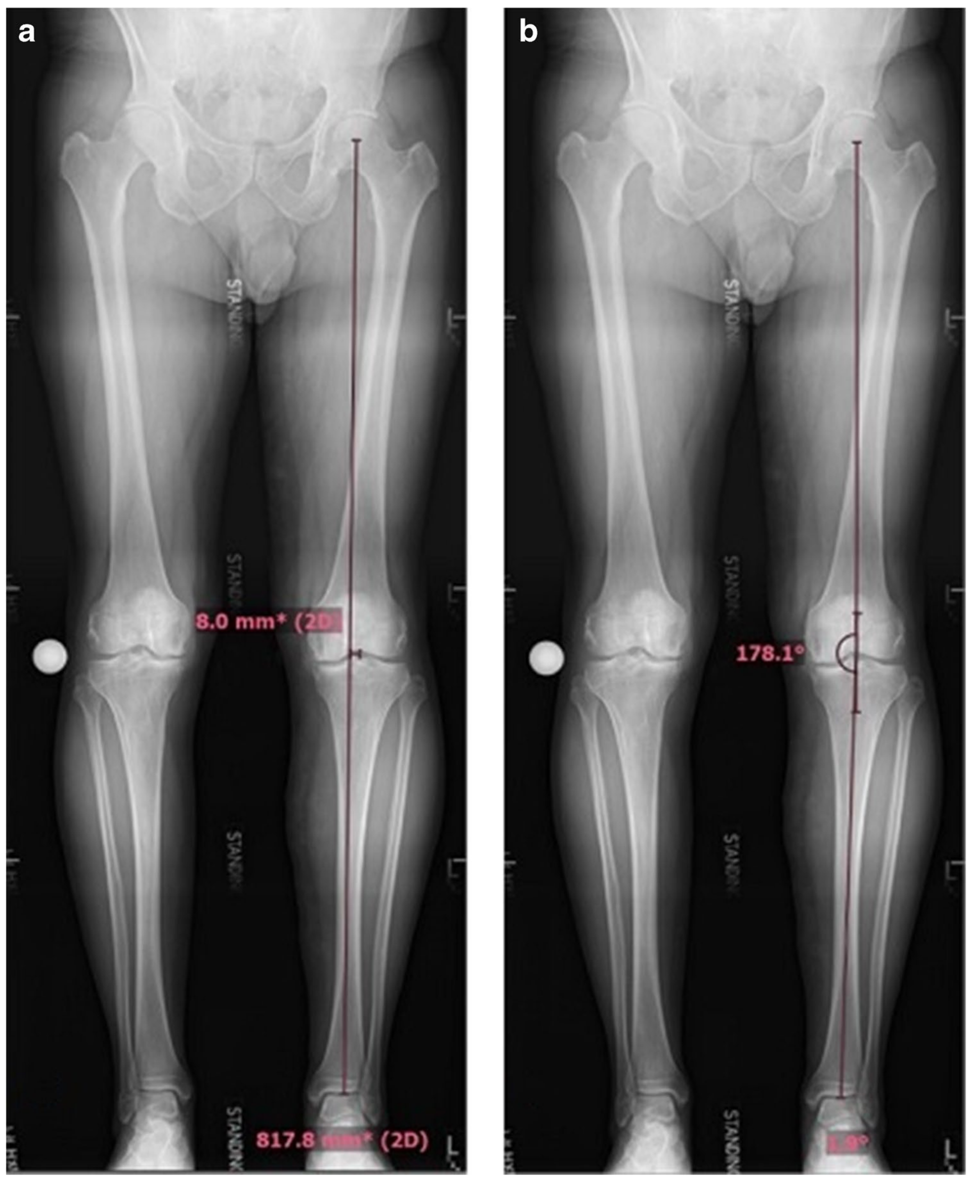

Fig. 2 **A** Measurement of the mechanical axis deviation (MAD) in a male patient. Mechanical axis deviation (MAD) was determined by drawing a straight-line axis from the center (intersection of the midline point) of the femoral head to the center of the tibial plafond and then recording the distance from this line to the center of the knee. **B** Measurement of the hip-knee-ankle angle (HKAA) in a male patient. Hip-knee-ankle angle (HKAA) was determined by using one axis running from the middle of the femoral head to the middle of the femoral notch and the other axis extending between the middle of the tibial notch to the middle of the tibial plafond

from the middle of the femoral head to the middle of femoral notch and the other axis extending between the middle of the tibial notch to the middle of the tibial plafond (Fig. 2). The medial proximal tibial angle (MPTA) and mechanical and anatomic lateral distal femoral angles (mLDFA and aLDFA respectively) were measured using the PACS "angle" tool. The MPTA is defined as the angle between the mechanical axis of the tibia and a line intersecting the medial- and lateral-most corners of the tibial epiphyses. The mLDFA is defined as the lateral-based angle measured between the mechanical axes of the femur and a line drawn tangent to the distal-most aspect of the distal femoral epiphysis [16]. aLDFA is defined as the lateral angle between the femoral anatomical axis and distal femoral line [17]. The LE alignment measurements are illustrated in Fig. 3. Knee joints were also evaluated for osteoarthritis and graded according to the Kellgren-Lawrence classification system. Patient age, weight, height, and body mass index (BMI) were obtained from the electronic medical record at the time the radiographs were taken.

Acquisition times for these measurements in the validation cohort were recorded. MAD was used to predict HKAA in the validation cohort using the previously calculated best-fit linear models from the discovery cohort.

Statistical analysis

Discovery cohort

The best predictor of HKAA was identified by using ordinary least-squares regression modeling. Shapiro-Wilks test was used to confirm that HKAA was approximately normally distributed. Correlations between lower extremity measurements with patients' demographic/clinical characteristics were calculated. Analysis of variance (ANOVA) was used to evaluate the association between MAD and Kellgren-Lawrence (KL) grades, and to evaluate the association between HKAA and KL grades. Tukey's honest significant difference (HSD) test

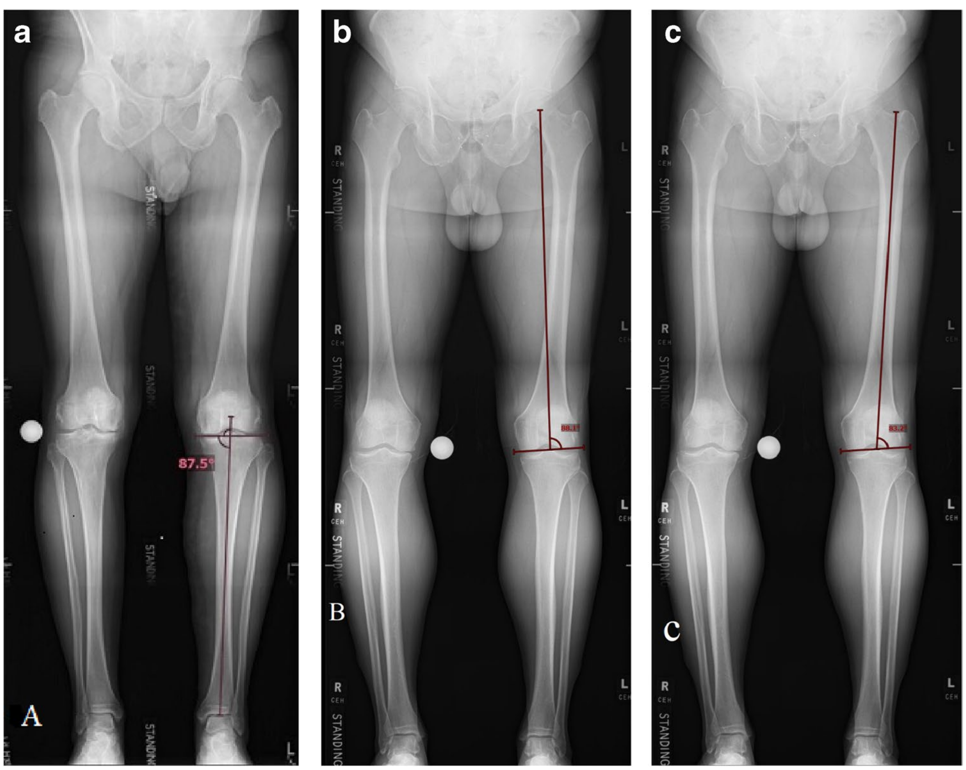

Fig. 3 **A** Standing hip-to-ankle radiographs of a male patient demonstrating the measurement of the medial proximal tibial angle (MPTA). The medial proximal tibial angle (MPTA) is defined as the angle between the mechanical axis of the tibia and a line intersecting the medial- and lateral-most corners of tibial epiphyses. **B** Standing hip-to-ankle radiographs of a male patient demonstrating the measurement of the mechanical lateral distal femoral angle (mLDFA). The mechanical lateral distal femoral angle (mLDFA) is defined as the lateral-based angle measured between the mechanical axes of the femur and a line drawn tangent to the distal-most aspect of the distal femoral epiphysis. **C** Standing hip-to-ankle radiographs of a male patient demonstrating the measurement of the anatomical lateral distal femoral angle (aLDFA). The anatomical lateral distal femoral angle (aLDFA) is defined as the lateral angle between the femoral anatomical axis and distal femoral line

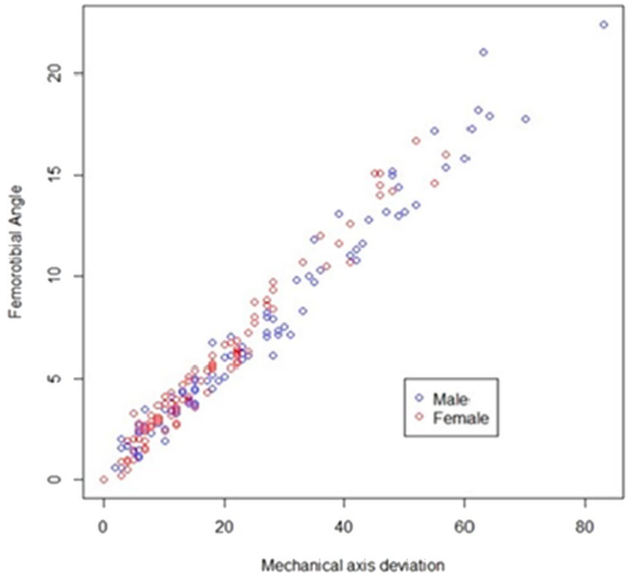

Fig. 4 Scatterplot comparing the mechanical axis deviation (MAD) to the hip-knee-ankle angle (HKAA) for both genders

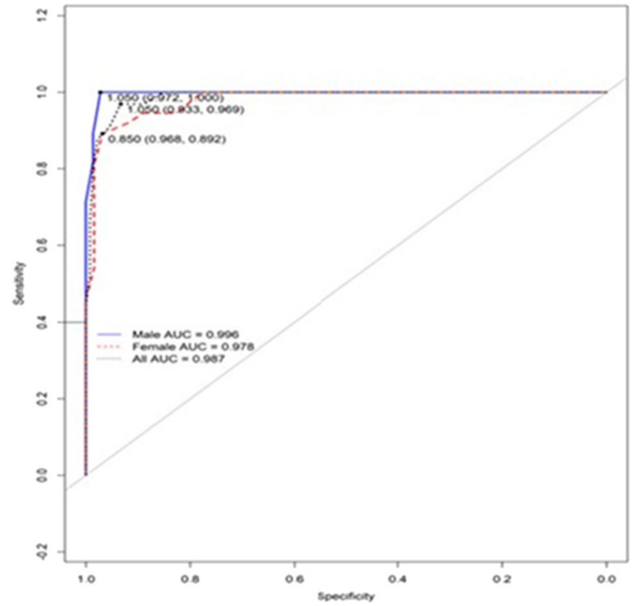

Fig. 5 Receiver operator characteristic (ROC) curves predicting the hip-knee-ankle angle (HKAA) using mechanical axis deviation (MAD) by gender

was used to evaluate whether there were differences between MAD and HKAA by KL grade.

Univariate linear regression was done using gender, and MAD as predictors of HKAA (Fig. 4). Multivariable linear regression modeling was performed to identify the best predictor of HKAA by including variables with p values < 0.20 in the univariate analysis. A best-fit multivariable model for prediction of HKAA deviation from neutral alignment using MAD was determined via linear regression analysis in the model development cohort. This model was used to predict the HKAA for each patient in the prospective validation cohort. The equations to predict the deviation of the HKAA from 180° are:

$$|180^\circ - HKAA_{male}| = 0.385 - 0.414 * male + 0.285 * MAD \text{ in millimeters} \quad (1)$$

$$|180^\circ - HKAA_{female}| = 0.385 + 0.285 * MAD \text{ in millimeters} \quad (2)$$

Receiver operator characteristic (ROC) curves were used to evaluate the performance of the MAD to predict HKAA by gender and height (Figs. 5 and 6). The area under the ROC curves (AUCs) were compared using DeLong's test.

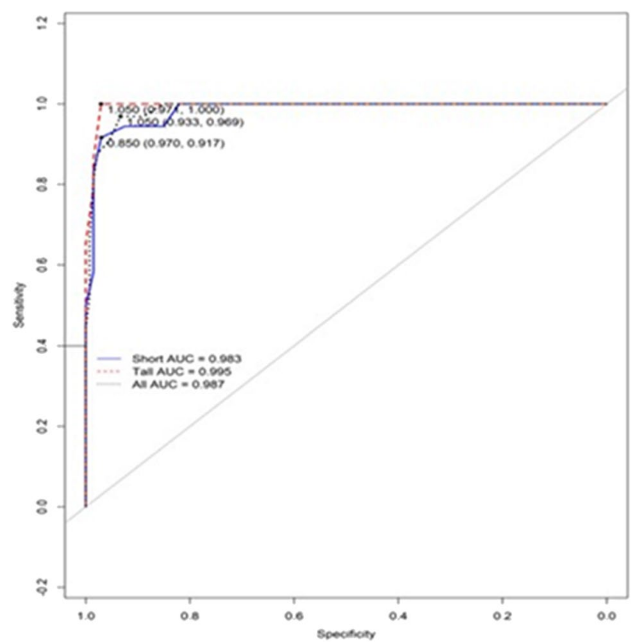

Fig. 6 Receiver operator characteristic (ROC) curves predicting the hip-knee-ankle angle (HKAA) using mechanical axis deviation (MAD) by whether a patient is above or below the median height

Validation cohort

Inter-rater and intra-rater reliability for MAD and HKAA measurements were assessed using intraclass correlation coefficients (ICC). Acquisition times for MAD and HKAA measures were compared using paired t tests.

The agreement between the observed HKAA and predicted HKAA values was assessed using Bland–Altman plots. All statistics were two-sided, and p values < 0.05 were considered statistically significant. Statistics were performed using Rv4.21 (Indianapolis, IN, USA) software.

Results

Discovery cohort

The discovery cohort consisted of 200 patients, 50% females, mean age 65.7 years (standard deviation (SD) 11.8 years) and 50% males, mean age 62.6 years (SD 14.6 years). Males were taller ($p < 0.001$) and heavier ($p < 0.001$) than females on average but showed no statistically significant difference in BMI ($p = 0.700$). Males had a longer mean lower extremity length than females, 84.7 cm (SD 4.6 cm) vs 77.5 cm (SD 4.6 cm) respectively, $p < 0.001$, with longer mean femoral and tibial lengths, 46.2 cm (SD 2.7) vs 42.4 cm (SD 2.5) and 38.7 cm (SD 2.1) vs 35.2 cm (SD 2.2) respectively. Males had greater mean MAD, 2.7 cm (SD 4.6 cm) vs 1.6 cm (SD 1.4 cm), and lower mean HKAA than females 174.9° (SD 6.8°) vs 177.6° (SD 6.2°) respectively ($p = 0.003$) (Table 1). Patient height was strongly correlated with lower extremity length ($r = 0.848$, $p < 0.001$), femoral length ($r = 0.82$, $p < 0.001$), and tibial length ($r = 0.84$, $p < 0.001$) but showed only weak correlation with intercondylar notch width. HKAA, MPTA, mLDFA, and aLDFA showed no correlation with patient height or lower extremity length.

BMI was negatively correlated with femur length ($r = -0.26$, $p < 0.001$), tibia length ($r = -0.18$, $p < 0.009$),

Table 1 Study patients' clinical and demographic variables

Variable	All ($n = 200$)	Males ($n = 100$)	Females ($n = 100$)	p value
Mean age in years (SD)	64.1 (13.4)	62.6 (14.6)	65.7 (11.8)	0.098
Race/ethnicity (n, %)				0.802
Asian	2 (1.0%)	2 (2.0%)	0 (0.0%)	
Black	15 (7.5%)	6 (6.0%)	9 (9.0%)	
Hispanic	6 (3.0%)	4 (4.0%)	2 (2.0%)	
Indian	2 (1.0%)	1 (1.0%)	1 (1.0%)	
NA	3 (1.5%)	2 (2.0%)	1 (1.0%)	
Native American	1 (0.5%)	1 (1.0%)	1 (1.0%)	
White	170 (85.0%)	84 (84.0%)	86 (86.0%)	
Mean height in cm (SD)	170.0 (10.6)	177.7 (7.7)	162.3 (7.1)	< 0.001
Mean weight in kg (SD)	91.1 (20.6)	98.5 (19.1)	83.8 (19.3)	< 0.001
Mean BMI in kg/m^2 (SD)	31.5 (6.9)	31.3 (7.0)	31.7 (6.8)	0.700
Kellgren-Lawrence score (n, %)				0.030
0	8 (4.0%)	6 (6.0%)	2 (2.0%)	
1	22 (11.0%)	17 (17.0%)	5 (5.0%)	
2	32 (16.0%)	13 (13.0%)	19 (19.0%)	
3	70 (35.0%)	31 (31.0%)	39 (39.0%)	
4	68 (34.0%)	33 (33.0%)	35 (35.0%)	
Kellgren-Lawrence score (n, %)				0.881
0, 1, 2, 3	132 (66%)	67 (67.0%)	65 (65.0%)	
4	68 (34%)	33 (33.0%)	35 (35.0%)	
Laterality (n, %)				0.888
Left	96 (48.0%)	47 (47.0%)	49 (49.0%)	
Mean lower extremity length in cm (SD)	81.1 (5.9)	84.7 (4.6)	77.5 (4.6)	< 0.001
Mean mechanical axis deviation in cm (SD)	2.0 (1.7)	2.7 (4.6)	1.6 (1.4)	0.024
Mean intercondylar notch width in cm (SD)	2.0 (0.19)	2.0 (0.21)	2.0 (0.17)	0.179
Mean femur length in cm (SD)	44.3 (3.2)	46.2 (2.7)	42.4 (2.5)	< 0.001
Mean tibia length in cm (SD)	36.9 (2.8)	38.7 (2.1)	35.2 (2.2)	< 0.001
Mean HKAA in degrees (SD)	176.2 (6.6)	174.9 (6.8)	177.6 (6.2)	0.003
Mean MPTA in degrees (SD)	86.5 (2.7)	85.8 (2.8)	87.2 (2.4)	< 0.001
Mean mLDFA in degrees (SD)	87.4 (2.7)	88.2 (2.9)	86.7 (2.3)	< 0.001
Mean aLDFA in degrees (SD)	81.9 (3.20)	82.8 (3.6)	81.1 (2.5)	< 0.001
Alignment (n, %)				0.070
Varus	135 (67.5%)	75 (75.0%)	60 (60.0%)	
Valgus	49 (24.5%)	19 (19.0%)	30 (30.0%)	
Neutral	16 (8.0%)	6 (6.0%)	10 (10.0%)	

and HKAA ($r = -0.32$, $p < 0.001$). BMI was positively correlated with mLDFA (0.32, $p < 0.001$) and aLDFA ($r = 0.29$, $p < 0.001$) (Table 2). MAD varied by KL grade ($F_{4,195} = 25.9$, $p < 0.001$). Tukey's HSD showed that there were significant differences between MAD for KL grade 4 and KL grades 0 ($p < 0.001$), 1 ($p < 0.001$), 2 ($p < 0.001$), and 3 ($p < 0.001$) respectively. Similarly, we found that HKAA varied by KL grade ($F_{4,195} = 23.4$, $p < 0.001$). Tukey's HSD showed that there were significant differences between HKAA for KL grade 4 and KL grades 0 ($p < 0.001$), 1 ($p < 0.001$), 2 ($p < 0.001$), and 3 ($p < 0.001$) respectively. We do note that there were no significant differences in the distribution of KL grade 4 versus other grades between males and females ($p = 0.881$) (Table 1).

Figure 4 is a scatterplot demonstrating that MAD is highly predictive of HKAA for both genders. MAD was strongly correlated with HKAA for both females and males ($R = 0.99$) $p < 0.001$. ROC analysis identified the optimal sex-specific MAD threshold to identify whether the HKAA was not normal (outside of the $180° \pm 3°$). MAD thresholds were also different for taller (individuals above the median height of 170 cm) and shorter (individuals below the median height of 170 cm) individuals. The optimal threshold for taller individuals (height > 170 cm) was a MAD of 10.5 mm, while the optimal threshold for shorter individuals (height < 170 cm) was a MAD of 8.5 mm.

Applying the MAD threshold for taller individuals of 10.5 mm to shorter individuals resulted in significantly worse prediction (AUC 0.920 vs. 0.983 using the shorter individual MAD threshold, $p = 0.005$).

ROC analysis identified the optimal MAD threshold to predict whether the HKAA was not normally (outside of the $180° \pm 3°$) different between males and females. The optimal MAD threshold for females was 0.85 cm (sensitivity of 0.892, specificity of 0.968, and AUC of 0.978), while the optimal MAD threshold for males was 1.05 cm (sensitivity of 1.00, specificity of 0.972, and AUC of 0.996). Applying the MAD threshold for men of 1.05 cm to women resulted in significantly worse prediction (AUC 0.917 vs. 0.972, $p = 0.005$).

Validation cohort

The intra-rater reliability for HKAA was 1.00 95% confidence interval (CI) (0.99, 1.00), and for MAD, it was 0.99 95% CI (0.99, 1.00). The inter-rater reliability for HKAA was 0.99 95% CI (0.99, 1.00), and for MAD, it was 0.99 95% CI (0.98, 1.00). Paired *t* tests were used to compare the time taken to measure HKAA to the time taken to measure MAD, and there was no significant difference seen for reader 1 ($p = 0.124$) nor for reader 2 ($p = 0.793$). Reader 1 took a mean (standard deviation) time of 10.6 (1.8) s for measuring MAD and 10.1 (1.3) s for measuring HKAA, while reader 2 took a mean (standard deviation) time of 11.1 (1.6) s for measuring MAD and 11.1 (1.6) s for measuring HKAA. The model was highly predictive of HKAA for both genders in the prospective validation cohort. Bland–Altman plots showed no significant bias (Fig. 7).

Table 2 Correlations between demographic variables and lower extremity measurements

Variables	Age	Height	Weight	BMI
Lower extremity length	−0.16 [<0.027]	0.85 [<0.001]	0.25 [<0.001]	−0.24 [<0.001]
Mechanical axis deviation	0.11 [0.112]	0.105 [0.139]	0.29 [<0.001]	0.26 [<0.001]
Intercondylar notch width	0.03 [0.636]	0.18 [0.010]	0.18 [<0.009]	0.08 [0.274]
Femur length	−0.14 [0.053]	0.82 [<0.001]	0.22 [<0.002]	−0.26 [<0.001]
Tibia length	−0.17 [0.019]	0.84 [<0.001]	0.29 [<0.001]	−0.18 [0.009]
HKAA	−0.11 [0.106]	0.02 [0.762]	−0.27 [<0.001]	−0.32 [<0.001]
MPTA	−0.12 [0.090]	−0.06 [0.370]	−0.11 [0.12]	−0.09 [0.221]
mLDFA	0.04 [0.534]	−0.05 [0.497]	0.25 [<0.001]	0.32 [<0.001]
aLDFA	−0.01 [0.914]	0.00 [0.948]	0.25 [<0.001]	0.29 [<0.001]

Values in square brackets are *p* values

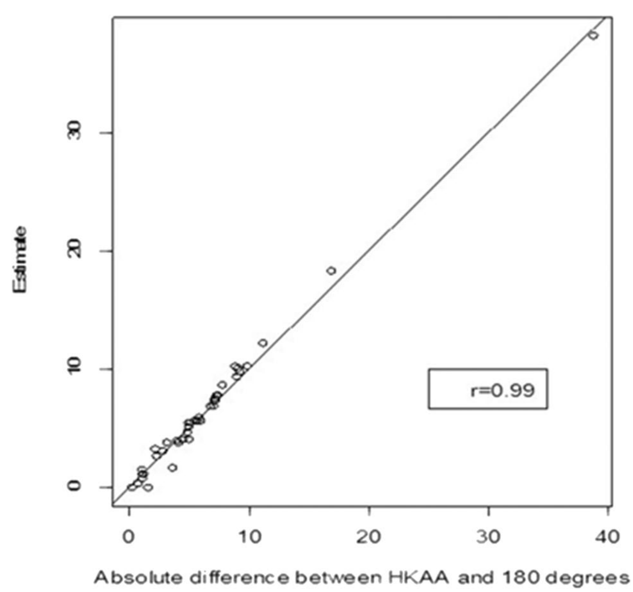

Fig. 7 Bland–Altman plot in the validation cohort showing no significant bias

Discussion

Coronal knee alignment is an important factor in the clinical outcome of TKA and remains a topic of interest. Despite improvements in conventional instrumentation and navigation, variation in component alignment can result in stiffness, pain, and decreased range of movement following TKA [18]. Although HKAA is the more clinically applicable measurement, MAD has been used for several decades to assess coronal knee alignment due to its simpler and more efficient measurement on film radiography [14, 19]. Despite a transition to digital imaging and PACS over the last two decades, measurement of MAD in place of HKAA may still be broadly practiced. We showed that HKAA can be easily measured with widely available digital imaging tools and that there was no difference in the reading time between MAD and HKAA between the two readers in our study. The perceived greater simplicity of measuring MAD over HKAA may no longer exist.

Our study showed that the MAD was strongly predictive of HKAA for both genders. Skytta et al. found similar correlation between MAD and HKAA [20]. Palad et al. showed that height was associated with HKAA deviation, meaning shorter patients showed HKAA deviation toward varus and that a greater varus angle was seen with females than males [13]. Our analysis showed that optimal MAD threshold to predict whether the HKAA was abnormal differed between genders. It also showed that the threshold to predict whether the HKAA was abnormal varied for people with different heights, specifically for taller individuals (> 170 cm) and for shorter individuals (< 170 cm). The greater threshold for males and taller individuals performed significantly worse in differentiating between normal and abnormal alignment in females and shorter individuals, indicating that several patient-specific thresholds would be necessary to accurately detect malalignment.

The study has a few limitations. It is a study of over 200 patients treated at a single tertiary care academic center, and the results may not be generalizable to the general population. Another limitation is that the alignment of the knee may vary between healthy individuals and osteoarthritic patients. These radiographs are typically taken for patients as part of planning for knee arthroplasties, so these patients typically have underlying osteoarthritis. The HKAA is a 2-dimensional measurement (a measurement in a single coronal plane) of a 3-dimensional structure (the lower extremity). We suspect that in future three-dimensional measurements of the lower extremity will be used to measure the coronal and sagittal angles, and that this information will be used to determine the optimal prosthesis to be used and the degree of surgical resection required to optimize the prosthesis alignment in all planes.

Despite HKAA being considered the gold standard measure of coronal knee alignment, measurement of MAD has largely supplanted HKAA due to the historical relative ease of use of MAD in comparison with HKAA. While MAD may be used as a surrogate for HKAA, the performance of MAD is affected by height and sex. With the ease of angular measurement facilitated by contemporary digital PACS systems, there is no longer any significant difference in the time required to measure HKAA versus MAD. Therefore, HKAA should be preferentially utilized to report coronal knee alignment.

Abbreviations *aLDFA*: Anatomical lateral distal femoral angle; *AUC* : Area under the curve; *BMI*: Body mass index; *CI*: Confidence interval; *HKAA*: Hip-knee-ankle angle; *ICC*: Intraclass correlation coefficients; *LE*: Lower extremity; *MAD*: Mechanical axis deviation; *mLDFA*: Mechanical lateral distal femoral angle; *MPTA*: Medial proximal tibial angle; *MSK*: Musculoskeletal; *PACS*: Picture archiving and communications system; *ROC*: Receiver operator characteristic; *SD*: Standard deviation; *TKA*: Total knee arthroplasty

Author contribution Joseph M. Bestic, Scott J. Billings—acquisition of data and interpretation of data analysis

Priyam Choudhury, Joseph M. Bestic, Ronnie Sebro, Jeffrey J. Peterson—drafting the article or revising it critically for important intellectual content

Ronnie Sebro—conception and design, analysis, interpretation of data analysis

Priyam Choudhury, Hillary W. Garner, Rupert O. Stanborough, Ronnie Sebro, Joseph M. Bestic—final approval of the version to be published

Ronnie Sebro—agreed to be accountable for all aspects of the work if questions arise related to its accuracy or integrity

Declarations

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare no competing interests.

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