

Correlation Between Demographic Data and Intraoperative Distal Femoral Anthropometry in Patients Undergoing Total Knee Arthroplasty

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Research Article

Keywords: Distal Femur, Anthropometry, Total knee arthroplasty, Nigeria, fAPD, fMLW, regression analysis

Posted Date: October 14th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11098453/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background: Accurate prediction of femoral component size is important, particularly in populations with diverse anthropometry. Radiographic templating is resource-intensive. Demographic parameters may offer a simple alternative, but data from African populations are scarce.

Objectives: To determine the correlation between demographic data and intraoperative distal femoral anthropometric measurements in patients undergoing primary total knee arthroplasty (TKA).

Methods: This cross-sectional study included 78 consecutive patients undergoing primary TKA for osteoarthritis at a regional Orthopaedic Hospital in Nigeria between May 2024 and April 2025. Preoperative age, sex, height, weight and BMI were recorded. Intraoperatively, anteroposterior diameter (fAPD) and mediolateral width (fMLW) of the resected distal femur were measured using a Vernier caliper. Pearson correlation and multivariate linear regression were performed using SPSS v28.

Results: Mean age was 66.12 ± 6.30 years. Mean fAPD was 58.65 ± 5.95 mm and fMLW was 70.11 ± 6.91 mm. Female sex predicted both fAPD [$B = -4.801$, $\beta = -.283$, $p = .021$] and fMLW [$B = -8.310$, $\beta = -.420$, $p < .001$]. Height predicted fAPD [$B = 139.245$, $\beta = 1.760$, $p = .045$], and age independently predicted fMLW [$B = -.230$, $\beta = -.210$, $p = .028$]. The fAPD model was significant [$F(5,72) = 3.84$, $p = .004$, $R^2 = 0.211$]. The fMLW model was significant [$F(5,72) = 8.10$, $p < .001$, $R^2 = 0.428$]. Weight and BMI were not significant predictors.

Conclusion: In this Nigerian cohort, intraoperative distal femoral dimensions were primarily determined by sex, with additional contributions from height for APD and age for MLW. These findings support consideration of sex, age, and height in preoperative planning for TKA.

Level of Evidence: III

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most successful and cost-effective orthopaedic procedures performed for end-stage knee osteoarthritis [1]. However, the long-term success of TKA depends not only on correct alignment and soft tissue balance, but also on appropriate sizing and positioning of the femoral and tibial components. Component mismatch, particularly femoral component overhang or under-sizing, has been associated with anterior knee pain, soft tissue irritation, patellar mal-tracking, and an increased risk of revision [2, 3].

Accurate preoperative estimation of component size is therefore essential for surgical planning. In many high-income centers, this is achieved using digital radiographic templating software. However, such resources are often unavailable in low- and middle-income countries (LMICs) due to cost and infrastructure limitations [4, 5]. In these settings where array of implant sizes may not be available, surgeons require an alternative method of templating to determine the range of component sizes that

should be available before embarking on TKA. Patient's demography was reported to be a better guide than radiographic templating in accurately predicting component size in TKA [6].

Anthropometric variation exists between populations and sexes. Several studies from Asian and Caucasian cohorts have reported correlations between demographic parameters such as height, weight, age and gender with distal femoral dimensions [7–10]. These data have informed the design of "population-specific" and "gender-specific" knee implants. However, data from African populations remain sparse [11]. Though, known differences in skeletal morphology and body habitus exist, it cannot be assumed that predictive models derived from Asian or Western cohorts are applicable to African or Nigerian patients.

Furthermore, sexual dimorphism in distal femoral morphology is well established, with females generally having a smaller anteroposterior dimension (APD) relative to mediolateral width (MLW) compared to males [12]. Age-related changes in bone geometry, especially the MLW may also influence component sizing [13]. Understanding these relationships in our local population is important for both clinical practice and for implant manufacturers seeking to expand into the African market.

Previous cadaveric anthropometric studies in our population have described the APD and MLW of the distal femur and compared them with commercially available implant sizes [14–16]. However, to our knowledge, there are no prospective studies from Nigeria that has reported direct intraoperative measurements of distal femoral anthropometry or correlated these dimensions with patient demographic parameters. The aim of this study was to determine the correlation between age, sex, height, weight, and Body Mass Index (BMI) with intraoperative distal femoral APD and MLW in Nigerian patients undergoing primary total knee arthroplasty (TKA). We hypothesized that demographic parameters would correlate significantly with femoral dimensions and could serve as a practical, cost-free adjunct for preoperative planning in resource-limited settings.

METHODS

Study Design and Setting

This was a prospective observational study conducted in the Department of Orthopaedics and Traumatology at a Regional Orthopaedic Hospital, Nigeria between May 2024 and April 2025. Ethical approval was obtained from the hospital's Health Research Ethics Committee with approval number NOH/HREC/01/23 and protocol number of 78/23. Non-probability sampling technique was used and written informed consent was obtained from all participants.

Study Population

Consecutive patients aged ≥ 50 years undergoing primary unilateral total knee arthroplasty (TKA) for end-stage knee osteoarthritis were recruited. Those who had previous knee surgery, post-traumatic arthritis, rheumatoid arthritis, significant lower limb deformity $>20^\circ$ varus/valgus, significant defect or femoral

hypoplasia, BMI >40 kg/m², and intraoperative complications requiring deviation from standard technique were excluded from the study.

Data Collection

Preoperative demographic data were recorded by a trained research assistant:

- i. Age - years
- ii. Sex - male/female
- iii. Height - meters, measured with stadiometer (Braun, UK) without footwear
- iv. Weight - kg, measured with calibrated scale (Hanson, India)
- v. BMI - calculated as weight(kg)/height(m)²

Intraoperative Measurements

All TKAs were performed by fellowship-trained arthroplasty surgeons using a standard medial parapatellar approach to the knee. Osteophytes, degenerated meniscal tissue and inflamed synovium were debrided to identify the actual dimensions of the bone surfaces that will be measured and improve surgical exposure. Intramedullary guide was placed with the angle of distal femur resection set at 4-7 degree of valgus and 9mm from the distal end of the femur. After distal femur cut, direct measurements of the distal femur were taken using a digital Vernier caliper with 0.01mm precision (Mitutoyo) as shown in figure 1.

1. Femoral Anteroposterior Diameter (fAPD): Distance from the most anterior point of the lateral femoral condyle to the most posterior point of the lateral femoral condyle, measured parallel to the surgical epicondylar axis. The same measurement was taken on the medial femoral condyle and a mean APD was calculated.
2. Femoral Mediolateral Width (fMLW): Distance between the most prominent points of the medial and lateral epicondyles.

Measurements were taken by the two surgeons to minimize inter-observer error. The average was recorded and interobserver reliability was calculated. The aspect ratio fAPD /fMLW was recorded for each patient, and the aspect ratio of the prosthesis used was also recorded by another research assistant.

The operation proceeded with tibial cut which was made perpendicular to the mechanical axis. The cut was 0mm on more affected condyle while 8-10 mm on the less affected condyle with 3-degree posterior slope tibial cutting block. The other cuts made on the femur to conform with the prosthesis to be implanted were anterior, posterior, anterior chamfer, posterior chamfer and box cut. Tibial preparation, trialing and soft tissue/gap balancing were done as necessary. The actual components were implanted and wound closed in layers.

Correlation

These MLW and APD were recorded in millimeters and correlated against the measured height, weight, BMI, age and gender. The anthropometric measurement that correlated best with the MLW and APD was taken as the most accurate in predicting femoral component size.

Sample Size Calculation

Sample size was calculated using G*Power 3.1. Assuming a moderate correlation of $r=0.4$ between demographic parameters and femoral dimensions, with $\alpha=0.05$ and power=80%, a minimum of 46 participants was required. We recruited 78 patients to account for 20% attrition.

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp; Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ SD while categorical variables were expressed as frequencies and percentages. Normality of data was assessed using the Shapiro-Wilk test. Pearson correlation coefficient was used to assess the relationship between demographic parameters and fAPD/fMLW. Correlation strength was classified as weak: $r < 0.3$, moderate: $r = 0.3-0.5$, and strong: $r > 0.5$. Step-wise multiple linear regression analysis was performed to identify independent predictors of fAPD and fMLW. The assumptions of linearity, normality of residuals, and homoscedasticity were met prior to regression analysis. Variables with $p < 0.10$ on univariate analysis were entered into the regression model. Statistical significance of variable tested with regression model was set at $p < 0.05$.

Results

Patient Demographics

A total of 78 patients were included in the final analysis. The mean age was 66.12 ± 6.25 years. There were 11 males and 67 females with male-to-female ratio of 1:6. The mean height, weight, and BMI were 1.60 ± 0.08 m, 76.92 ± 11.75 kg, and 30.08 ± 4.31 kg/m² respectively (Table 1).

Table 1: Patient Demographic and Clinical Characteristics (n = 78)

Variables	n (%)
Gender	
Female	67(85.9)
Male	11(14.1)
Age (Mean ± SD) years	66.12±6.25
Mean Height (meters)	1.60 ±0.08
Mean Weight (kg)	76.92±11.75
BMI, kg/m²	30.08±4.31
Laterality	
Right	50(64.1)
Left	28(35.9)

Intraoperative Femoral Morphometric Measurements

The mean intraoperative anteroposterior diameter of the distal femur (fAPD) was 58.65 ± 5.95 mm, with a range of 42.35 to 72.20 mm. The mean mediolateral width of the distal femur (fMLW) was 70.11 ± 6.91 mm, with a range of 58.30 to 90.55 mm. When measured separately, the mean APD of the medial condyle was 59.71 ± 6.00 mm and the mean APD of the lateral condyle was 57.59 ± 6.82 mm (Table 2). The aspect ratio was 1.2

Table 2: Intraoperative Distal Femoral Dimensions

Variables	Mean±SD	Range
APD lateral condyle(mm)	57.59±6.82	34.00-71.10
APD medial condyle (mm)	59.71±6.00	42.55-73.50
fAPD (mm)	58.65±5.95	42.35-72.20
fMLW (mm)	70.11±6.91	58.30-90.55

Correlation of Demographic Parameters with Femoral Dimensions

On univariate analysis, female sex moderately correlated with smaller fAPD [$r = -0.367$, $p < 0.001$] and strongly correlated with smaller fMLW [$r = -0.542$, $p < 0.001$]. Height was positively correlated with both fAPD [$r = 0.290$, $p = 0.010$] and fMLW [$r = 0.311$, $p = 0.006$]. BMI was weakly correlated with fAPD [$r = -0.252$, $p = 0.026$] but not with fMLW. Age and weight showed no significant correlation with either fAPD or fMLW (Table 3).

Table 3: Pearson Correlation Between Demographic Parameters and Femoral Dimensions

Variable	fAPD		fMLW	
	R	P value	r	P value
Sex	-0.367	<0.001	-0.542	<0.001
Height	0.290	0.010	0.311	0.006
BMI	-0.252	0.026	-0.107	0.352
Weight	-0.075	0.515	0.071	0.540
Age	-0.022	0.848	-0.140	0.220

Predictors of Femoral Dimensions

Multiple linear regression analysis was performed to identify independent predictors of fAPD and fMLW. For fAPD, the regression model was statistically significant [$F(5,72) = 3.842$, $p = 0.004$] and explained 21.1% of the variation [$R^2 = 0.211$]. Female sex [$B = -4.80$, $\beta = -0.283$, $p = 0.021$] and height [$B = 139.25$, $\beta = 1.760$, $p = 0.045$] were significant independent predictors. After adjusting for other variables, females had an fAPD that was 4.80 mm smaller than males, and for every 1 cm increase in height, fAPD increased by 1.39 mm. Age, weight, and BMI were not significant independent predictors. The regression equation is as shown in Table 4a.

Table 4a: Multiple linear regression analysis for prediction of fAPD(n=78)

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-131.329	105.240		-1.411	.162
Age(years)	-.038	.102	-.041	-.373	.710
Sex	-4.801	2.031	-.283	-2.364	.021
Height(cm)	139.245	68.110	1.760	2.045	.045
Weight(kg)	-1.102	.701	-2.179	-1.572	.120
BMI(kg/m ²)	2.610	1.780	1.893	1.467	.147

Model Fit: $F(5,72) = 3.842$, $p = 0.004$

$R^2 = 0.211 \rightarrow 21.1\%$ of variance explained

The estimated regression equation

fAPD (mm) = -131.33 - 0.038(Age) - 4.80(Sex) + 139.25(Height) - 1.10(Weight) + 2.61(BMI)

Sex was coded as 1 = Female, 0 = Male

For fMLW, the regression model was statistically significant [$F(5,72) = 8.10$, $p < 0.001$] and explained 42.8% of the variation. Female sex [$B = -8.31$, $\beta = -0.42$, $p < 0.001$] and age [$B = -0.23$, $\beta = -0.21$, $p = 0.028$] were significant independent predictors. After adjusting for other variables, females had an fMLW that was 8.31 mm smaller than males, and for every 1-year increase in age, fMLW decreased by 0.23 mm. Height, weight, and BMI were not significant independent predictors (Table 4b). The regression equation is $fMLW(mm) = -52.1 - 0.23(Age) - 8.31(Sex) + 68.4(Height) - 0.79(Weight) + 1.88(BMI)$.

Table 4b: Multiple linear regression analysis for prediction of fMLW(n=78)

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	Beta	Std. Error	Beta		
(Constant)	-52.1	108.3		-.48	.632
Age (years)	-.23	.10	-.21	-2.25	.028
Sex	-8.31	2.05	-.42	-4.05	<.001
Height(cm)	68.4	68.9	.74	0.99	.324
Weight (Kg)	-.79	.68	-1.34	-1.16	.250
BMI (kg/m2)	1.88	1.75	1.17	1.07	.288

Model Fit: F (5,72) = 8.10, p < 0.001

R² = 0.428 → 42.8% of variance explained

The estimated regression equation

fMLW(mm) = -52.1 - 0.23(Age) - 8.31(Sex) + 68.4(Height) - 0.79(Weight) + 1.88(BMI)

Sex was coded as 1 = Female, 0 = Male

Discussion

The present study evaluated the correlation between patient demographic parameters and intraoperative distal femoral anthropometry in Nigerian patients undergoing primary TKA. The key findings were that sex was an independent predictor of both fAPD and fMLW, while height independently predicted fAPD and age independently predicted fMLW. Weight and BMI did not show significant correlation with either femoral dimension.

The mean intra-operative fAPD and fMLW in our study were 58.65 ± 6.0 mm and 70.11 ± 6.91 mm, respectively. These dimensions are approximately 5 mm smaller than those reported in Korean and Caucasian intra-operative studies [8, 9], but closely approximate data from Kenyan patients with mean values of 59.6 ± 5.19 mm and 68.4 ± 5.19 mm [11]. This suggests that Sub-Saharan Africans share similar distal femoral morphology characterized by smaller absolute size. The larger values in prior Nigerian cadaveric studies likely reflect methodological differences, as cadaveric measurements include osteophytes and denuded cartilage, whereas intra-operative measurements after bone resection represent the true articular geometry that interfaces with the implant [14–16]. The fact that Blevin et al. [9] and Chung et al. [8] also used intra-operative techniques yet reported larger dimensions further supports true ethnic variation rather than technique bias.

Consistent with global data, female sex independently predicted smaller dimensions, with females having 4.8 mm smaller fAPD and 8.3 mm smaller fMLW than males after adjusting for height, weight, BMI, and age. This is comparable to findings by Mahfouz et al. [17] and Cheng et al. [18], who also

reported smaller femoral dimensions in females. This larger magnitude of difference in our cohort is clinically relevant for TKA, as it may contribute to mediolateral overhang or undercoverage if gender-neutral implants are used. Hence, female patients are more likely to require smaller femoral components.

In our cohort, Age emerged as an independent predictor of fMLW, with fMLW decreasing by 0.23 mm for every 1-year increase in age. This age-related narrowing of fMLW has not been consistently reported in literature and may reflect morphometric changes in shape of the distal femur or subchondral bone remodeling with ageing [19]. Given that our mean age was 66.12 years, this finding suggests that elderly Nigerian patients may be at even greater risk of ML undersizing with standard implants. Contrary to our finding, age was not a significant predictor of femoral component dimensions in an Indian population [20].

Height was found to be an independent predictor of fAPD but not fMLW. This aligns with the concept that overall body size and longitudinal skeletal growth correlate more with anteroposterior dimensions of long bones. A similar strong positive relationship between height and fAPD was reported by Blevin et al. [9]. In resource-limited settings like Nigeria, where routine preoperative templating is not available, height may serve as a simple alternative for estimating fAPD and narrowing down trial component sizes intraoperatively.

Weight and BMI showed no independent effect on distal femoral dimensions. This contrasts the findings of some authors where patient demography —weight, height and sex —correlated with femoral component size in a linear fashion were [9, 21, 22]. The lack of correlation in our population may be because BMI reflects soft tissue mass more than skeletal dimensions, and distal femoral morphology is determined more by genetics and sex than by body habitus. The regression models explained 21.1% of the variance in fAPD and 42.8% of the variance in fMLW. This indicates that while demographic parameters — age, height, and sex — are useful predictors, a substantial portion of the variation in femoral dimensions is due to other factors such as genetics, ethnicity, and individual anatomical variation not captured in this study.

Beyond absolute size, the shape of the distal femur is equally important for implant fit. The mean aspect ratio, fMLW/fAPD, in our cohort was 1.20, which is higher than the ~1.13–1.15 reported for Asian implants [8]. This indicates that distal femurs of Nigerians are relatively wider for a given AP dimension. The combination of a smaller AP and a proportionally wider ML creates a sizing dilemma during TKA. Sizing the femoral component by AP dimension to avoid anterior notching may result in mediolateral overhang and soft tissue irritation. Conversely, sizing by ML width to avoid overhang will lead to AP undersizing, flexion gap instability, and increased risk of anterior femoral notching. These findings imply that implants designed from Western anthropometric databases may not be optimal for Nigerian patients. The higher aspect ratio and smaller absolute dimensions observed in our population underscores the need for ethnic-specific implant designs with a narrower AP for a given MLW. In settings

where such implants are unavailable, careful intra-operative anthropometric assessment and trialing remain critical to minimize complications related to component mismatch.

Preoperative templating with radiographs or Computed Tomography (CT) is the gold standard for implant size prediction but is often unavailable in low-resource settings due to cost and infrastructure limitations [5]. In such contexts, simple demographic parameters can serve as practical adjuncts. Our data suggest that knowing a patient's height and sex can provide a reasonable estimation of femoral component size prior to surgery. For example, a short female patient is more likely to require a smaller femoral component, while a tall male will likely require a larger one. This can aid in preoperative planning, inventory management, and counseling of patients, especially where implant trials are limited.

The main strength of this study is that measurements were taken intraoperatively using a standardized technique, thus reflecting true osseous dimensions rather than radiographic or cadaveric estimates. All measurements were performed by two individuals to minimize inter-observer error. It also provides the first intra-operative anthropometric data for West Africans with focus on Nigerian population where data on distal femoral anthropometry are scarce.

This study has some limitations. First, it was conducted at a single tertiary center with a moderate sample size of 78 patients. This may not be fully representative of the entire Nigerian population. Second, we did not correlate our measurements with preoperative radiographs or CT scans to test accuracy. This was beyond the scope of our objectives, as intraoperative measurement reflects the real-time dimensions encountered during surgery. Third, we did not include foot length or shoe size, which have been reported as predictors in other studies and will be addressed in a subsequent analysis of tibial dimensions. We recommend future multicenter studies with a larger sample size to validate these findings, develop population-specific sizing guidelines, and determine whether age-adjusted or ethnic-specific implants improve radiographic fit and clinical outcomes.

Conclusion

In this Nigerian population, intraoperative distal femoral dimensions were primarily determined by sex, with additional independent contributions from height for fAPD and age for fMLW. These findings underscore that demographic factors must be considered during preoperative planning for TKA in our setting. Given the smaller absolute dimensions and higher aspect ratio observed compared to Western populations, reliance on standard implant sizing systems may lead to component mismatch. Therefore, there is a need to develop Nigerian-specific femoral component sizing guidelines that account for sex, age, and height. Such population-specific guidelines would optimize implant fit, reduce the risk of mediolateral overhang and flexion instability during TKA.

Abbreviations

Total knee arthroplasty (TKA), Low and middle income countries (LMIC), Femoral anteroposterior diameter (fAPD), Femoral mediolateral width (fMLW), Body Mass Index (BMI), Statistical Package for

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Health Research Ethics Committee of National Orthopaedic Hospital, Igbobi. Lagos on 13th November 2023 with approval number NOH/HREC/01/23 and protocol number of 78/23.. The research was conducted in total compliance with Helsinki declaration

Consent for publication:

All authors gave consent to submit this manuscript for publication in your journal

Availability of data and materials

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

Competing Interests:

The authors declare no competing interests

Funding :

The authors did not receive any funds or grants for this study

Authors' contributions

OL, OO and TA conceived and designed the study. OL, TA and KAA measured the data. The statistical analysis was performed by OL, KAA and IEG. First draft of the manuscript was completed by KAA while the final manuscript was revised by all authors.

Acknowledgements

The authors acknowledged the enormous assistance rendered by resident doctors and arthroplasty surgeons for their support during the course of the study.

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Figures

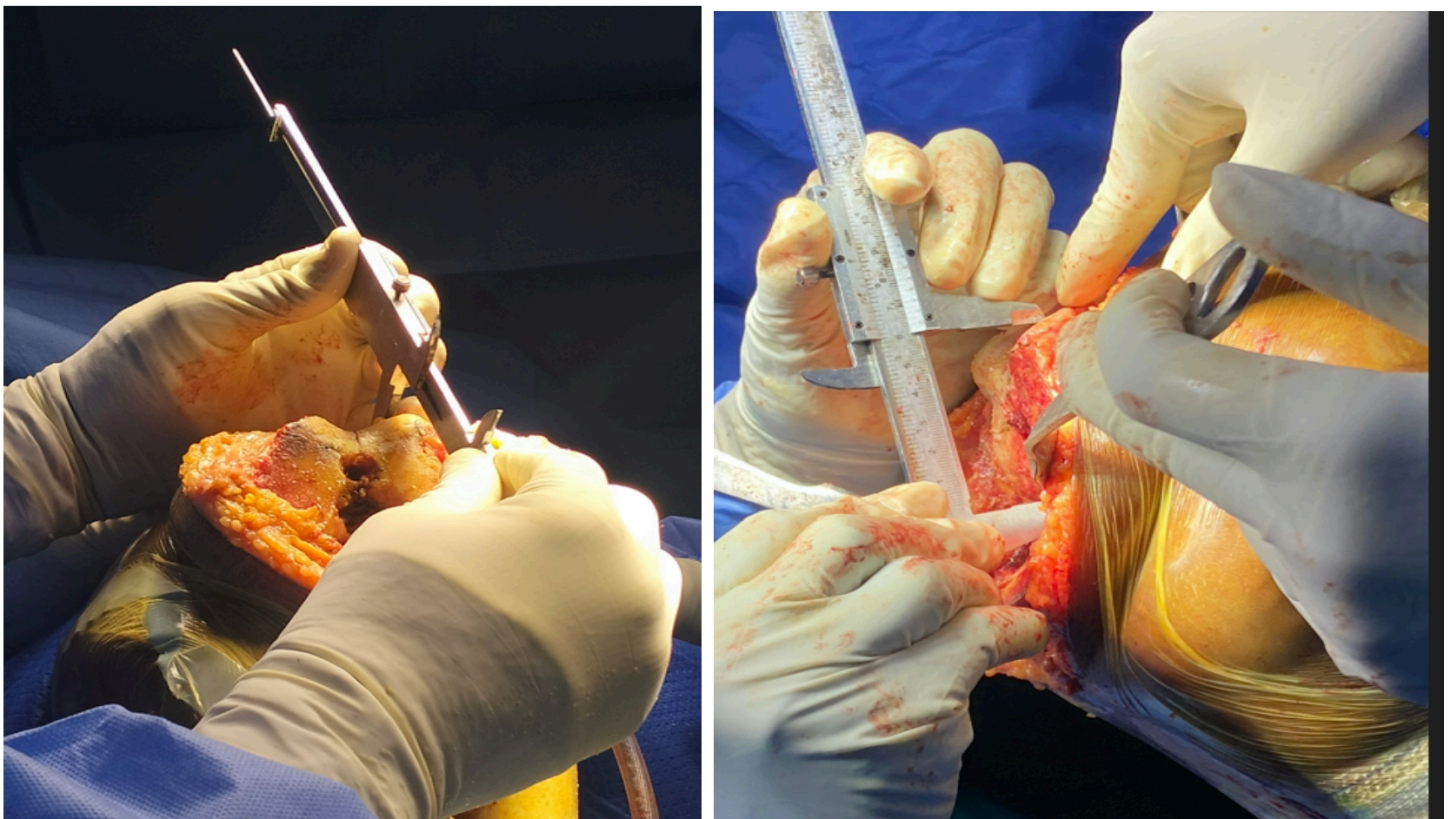


Figure 1

Intra-operative caliper measurement of femoral anteroposterior diameter(APD) and mediolateral width (MLW)