ASSESSING THE ACCURACY OF PRESUMPTIVE DISTAL FEMORAL CUTS IN THE CONDUCT OF CONVENTIONAL TOTAL KNEE REPLACEMENT IN KENYAN PATIENTS WITH END STAGE OSTEOARTHRITIS OF THE KNEE

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ABSTRACT

Background: Total Knee Replacements in our setting are performed using conventional techniques. This involves use of an intramedullary rod and jig to perform the Distal Femoral Cut (DFC). Ideally the magnitude of the Valgus Correction Angle (VCA) used to perform the DFC should equal the angle subtended by the femoral anatomical and mechanical axes at the knee. This relationship can be determined preoperatively using whole lower limb radiographs or presumed to be ideal and of a magnitude between 5^0 and 7^0 (6^0 being common). Assumption may be erroneous given the influence of Coronal Femoral Bowing (CFB) and the Neck Shaft Angle (NSA) on the relationship.

Objective: The purpose of this study was to determine the accuracy of presumptive cuts in our setting.

Methods: This was a cross sectional study in four orthopaedic centers in Kenya namely Kenyatta National Hospital (KNH), St Francis Community Hospital Kasarani, PCEA Kikuyu Hospital and the Aga Khan University Hospital Nairobi. Patients with end stage osteoarthritis of the knee scheduled for surgery were screened. Whole lower limb radiographs with limbs in 15^0 of internal rotation were taken and used to determine the VCA, CFB and NSA. The rate of error with use of presumptive cuts within prescribed limits was then determined.

Results: Eighty two limbs in 48 patients were studied. Fifty nine were in varus 21 in valgus and 2 in neutral alignment. The average VCA for all libs was 6.29^0(sd 1.80^0). Considering only limbs in varus alignment the VCA averaged 6.51^0(sd 1.95^0). Use of presumptive cuts of 6^0 in these limbs would potentially result in erroneous cuts in 9.8% of limbs in varus alignment. There was a strong positive correlation between CFB and the VCA.

Conclusions: Routine use of whole lower limb radiographs could improve the accuracy of DFC. In their absence use a VCA of greater magnitude within the prescribed limits in patients with significant clinical varus alignment.

Key words: Valgus correction angle, Coronal femoral bowing, Distal femoral cut, Neck Shaft Angle, Total Knee Replacement

INTRODUCTION

The objective of the Distal Femoral Cut (DFC) during Total Knee Replacement (TKR), is to place the femoral component perpendicular to the femur's mechanical axis. During conduct of conventional TKR, the intramedullary rod of the cutting jig references the anatomical axis of the distal femur. To achieve this objective, the Valgus Correction Angle (VCA) used to perform the DFC has to equal the angle subtended by the mechanical and the distal femoral anatomical axes at the knee joint (Figure 1).

To perform the DFC the surgeon can take one of two courses. Assume an ideal relationship between the axes and perform a presumptive cut using a VCA between 5^0 and 7^0. Alternatively he can perform a preoperative whole lower limb radiograph to accurately determine the magnitude of the relationship between the two axes.

Review of the literature reveals differing opinions regarding utility of routine preoperative whole lower limb radiographs to determine the VCA. Khardakwar *et al* (1) recommended performance of presumptive DFCs using a VCA between 50 and 70 during routine TKR reserving preoperative whole lower limb radiographs for patients with a history of femur fractures. McGory and Trousdale randomized patients with End Stage Osteoarthritis of the Knee (ESOAK) scheduled for TKR into two groups. One group had whole lower limb radiographs to determine the VCA and the second had presumptive cuts performed. They reported no significant differences between the groups with respect to postoperative limb alignment (2).

Other authors of a contrary opinion recommend routine use of preoperative whole lower limb radiographs to determine the VCA. They argue variations between populations with respect to femoral anatomical features that act as determinants of the relationship between the mechanical and the distal femoral anatomical axes, namely Coronal Femoral Bowing (CFB) and the Neck Shaft Angle (NSA), make presumptive cuts inaccurate.

Considering the effect of CFB on the VCA, several authors have reported assuming an ideal relationship and performing presumptive cuts would potentially result in an erroneous cut in a proportion of limbs. Mullaji *et al* (3) reported significant degrees of lateral CFB in patients with ESOAK and varus alignment. Use of presumptive cuts of 6^0 in the limbs they studied would potentially result in errors in the DFC in 11%. Yau *et al* (4) in a similar study reported use of presumptive cuts of 6^0 would potentially result in an error in the DFC in 31% of limbs studied. Teter *et al* (5) reported errors in the DFC in 8.5% of limbs studied and cited CFB as one cause. All authors recommended routine use of preoperative whole lower limb radiographs to determine the VCA in patients scheduled for TKR.

Bardakos *et al* (6) studied the effect of the NSA on the VCA demonstrating that coxa valga reduced the offset of the femoral anatomical axis from the mechanical axis reducing the magnitude of the VCA. Coxa vara had the opposite effect.

The position of the femoral component in the coronal plane is one determinant of postoperative limb alignment in the coronal plane. Other authors (7-14) have reported this alignment may affect prosthesis survival with limbs whose alignment is outside prescribed limits having higher rates of failure and revision secondary to aseptic loosening, anterior knee pain and tibial fracture. Therefore, use of presumptive cuts may increase the rate of prosthetic failure and revision if used in populations with femoral anatomical features that increase the magnitude of the VCA in patients with ESOAK.

The objective of this study was to determine the pattern of variation of the VCA, its determinants (CFB and the NSA) and their effect on the accuracy of presumptive cuts in the study population. Given the population of study is of African descent the hypothesis was that even in the incidence of CFB was significant in, the relative coxa valga reported in persons of African descent may vitiate its effect making use of presumptive cuts accurate (15,16).

MATERIALS AND METHODS

This was a cross sectional study conducted in four orthopaedic centers in Kenya namely Kenyatta National Hospital (KNH), St Francis Community Hospital Kasarani, PCEA Kikuyu Hospital and the Aga Khan University Hospital Nairobi. Approval was sought from the ethical committees following which patients with diagnoses of bilateral or unilateral ESOAK scheduled for TKR were selected. Selected limbs had a Kellgren Lawrence osteoarthritis score of at least three causing limitation of mobility as demonstrated by time up and go and stair climbing tests (17,18).

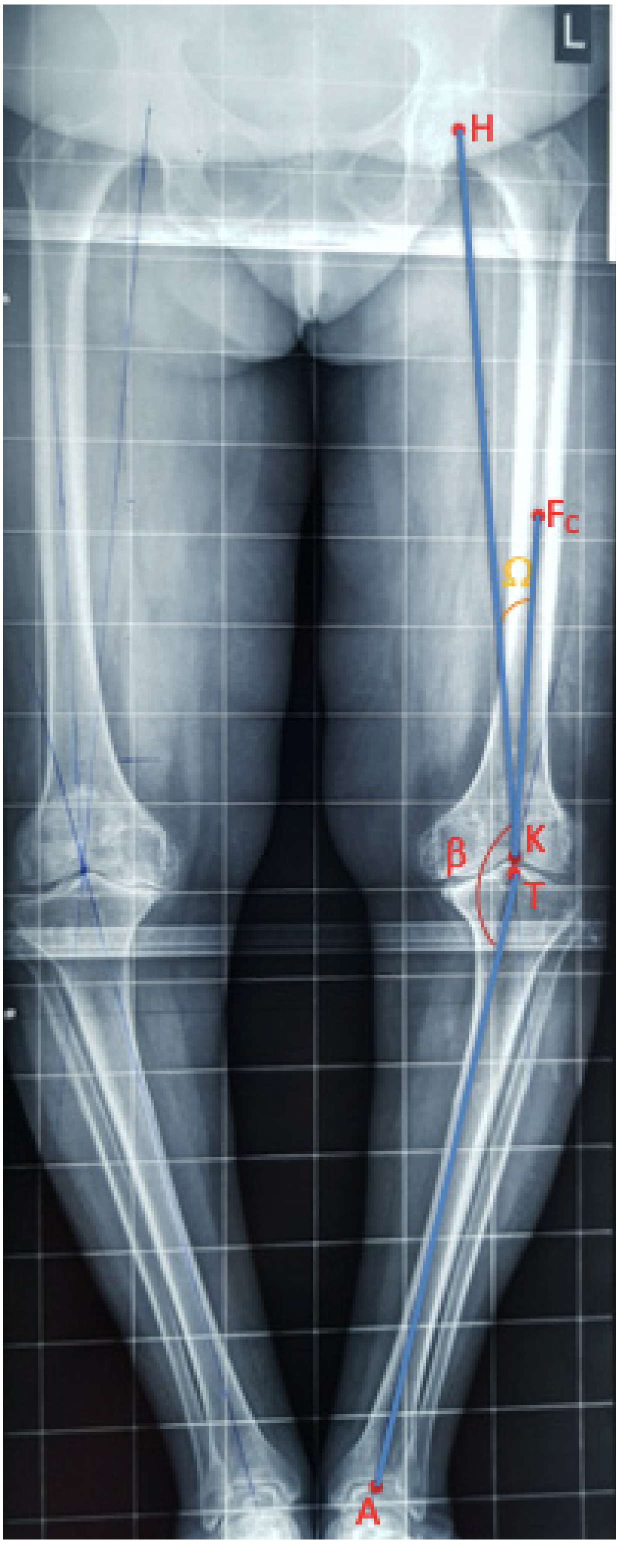
Limbs with flexion contractures greater than 20^0 were excluded given that this makes measurements of interest inaccurate secondary to tibial rotation on the femur (19,20). Limbs with history of femoral or tibial fractures were also excluded. Enrolled patients had consent taken, including for the risk of exposure to ionising radiation.

Weight bearing whole lower limb radiographs were taken with limbs in 15^0 of internal rotation ensuring the femoral neck was radiographed along its longest axis for determination of the NSA. Land marks used to make the measurements of interest were as described by Mullaji *et al* (3).

1. To measure limb alignment and VCA (Figure 1)
(i) H: a point at the centre of the femoral head determined using Moses' circles
(ii) K: a point at the apex of the intercondylar notch
(iii) T: a point in between the tibial tubercles
(iv) A: a point at the centre of the ankle joint

Figure 1

Shows landmarks and axes used to measure the lower limb alignment and the valgus correction angle



- HK: mechanical axis of the femur
- TA: mechanical axis of the tibia
- HKAA(β): Hip Knee Ankle Angle: describes the alignment of the lower limb
- F_CK: Anatomical axis of the distal femur. Path followed by the intramedullary rod during the DFC
- Ω: Ideal VCA to perform the DFC

2. To measure the angle of coronal femoral bowing (Figure 2)

(i) FP: a point bisecting the femur at the lower end of the lesser trochanter

(ii) FD: a point bisecting the femoral shaft at 10 cm above the line of the knee joint

(iii) Fc: a point bisecting the femoral shaft midway between FP and FD

Figure 2

Shows the landmarks and axes used to measure the bow of the femur

- F_DF_C: Anatomical axis of the distal femur
- F_PF_C: Anatomical axis of the proximal femur
- α: The angle subtended by FDFC and FPFC, the angle of coronal femoral bowing

Angles of interest were measured in 82 limbs that met the inclusion criteria. Data was entered into SPSS version 22 for analysis using parametric and non-parametric tests.

RESULTS

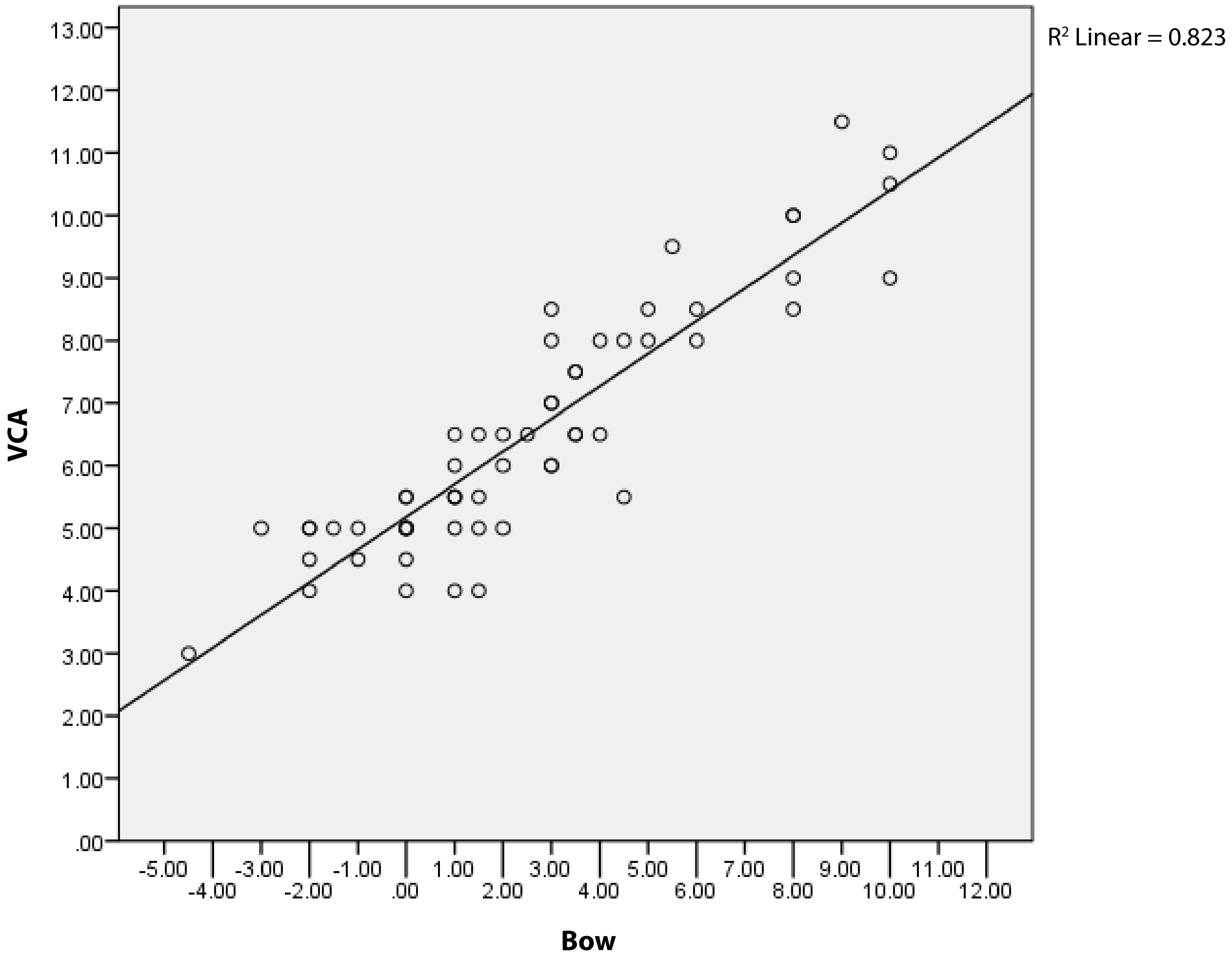
Of the 82 limbs studied, 59 (72%) were in varus (HKAA < 180^0), 21(25.6%) in valgus (HKAA >180^0) and 2 (2.4%) in neutral alignment (HKAA= 180^0). Considering the parameters of interest, measures of central tendency are summarised in Table 1.

Table 1
Measures of central tendency

Alignment (n)	VCA^0(sd)	CFB^0(sd)	NSA^0(sd)
Varus (59)	6.51 (1.95)	2.54 (3.39)	125.5 (5.85)
Valgus (21)	5.81 (1.18)	2.45 (2.39)	125.81 (6.91)
All limbs (82)	6.29 (1.80)	2.45 (3.14)	126.37 (6.31)

There was a positive correlation between CFB and the VCA. This correlation was strong for all limbs regardless of alignment; however, the correlation was stronger when only varus limbs were considered as demonstrated in Figure 3.

Figure 3
Shows positive correlation between bow and valgus correction angle for 59 limbs in varus alignment

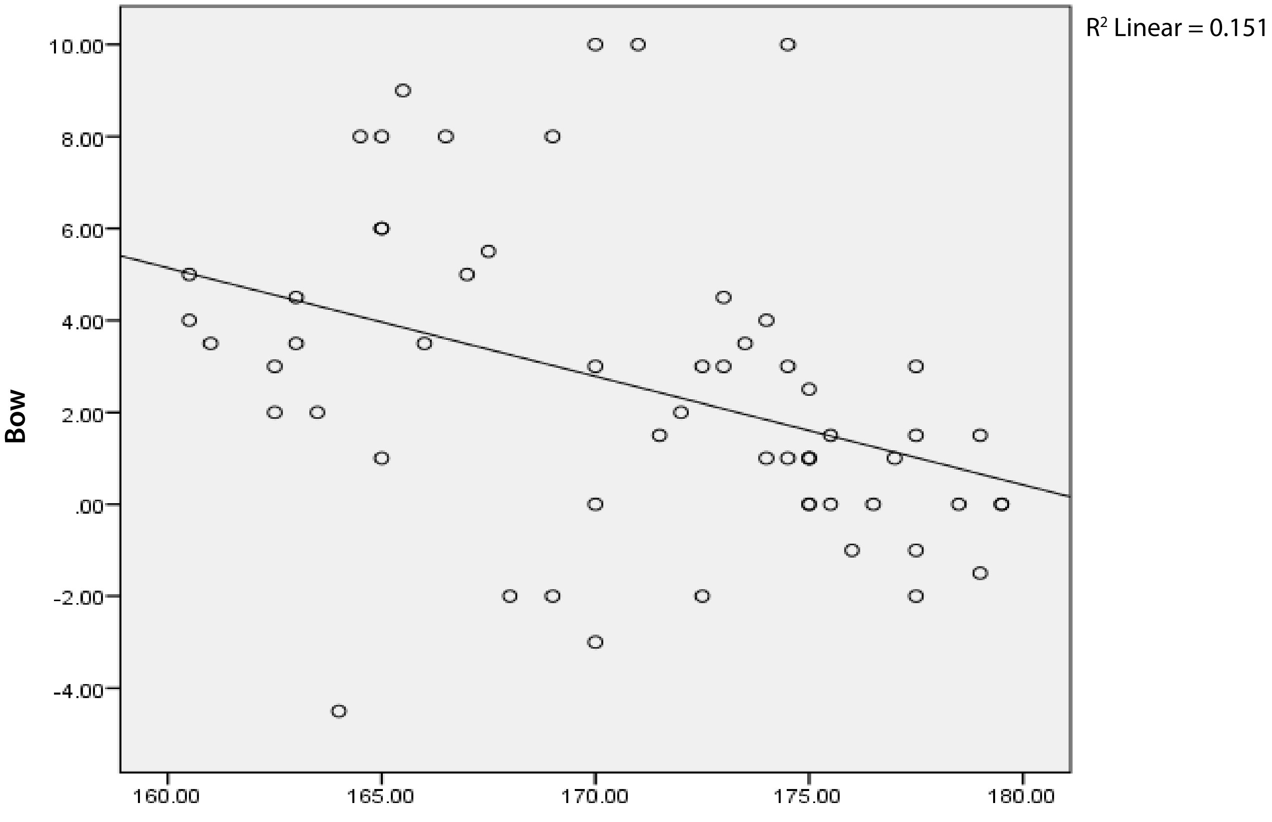


Considering the 59 varus limbs there was a negative correlation between CF Band limb alignment shown in Figure 4. All correlations were significant at p < 0.01.

The effect of the NSA on the VCA was assessed for the 59 varus limbs. Analysis of covariance was performed to determine if there was a difference in the VCA between patients with coxa vara and those with coxa valga.

Figure 4

Shows the negative correlation between limb alignment in the coronal plane and the valgus correction angle for the limbs in varus



After controlling for within group variation attributable to bowing of the femur, the VCA was compared between patients with coxa valga and those with coxa vara. The difference was significant at p (0.037) < 0.05 (Table 1) indicating there was significant difference between patients with coxa valga and coxa vara with respect to the VCA once variation due to CFB was controlled for.

Table 2

Results of analysis of covariance with lateral bowing as the covariate, neck shaft angle as the categorical variable and valgus correction angle as the continuous dependent variable

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected model	184.995a	2	92.498	142.890	.000
Intercept	998.058	1	998.058	1541.795	.000
BOW	180.725	1	180.725	279.184	.000
NSA	2.969	1	2.969	4.587	.037
Error	36.251	56	.647		
Total	2720.500	59			
Corrected Total	221.246	58			

a. R Squared = .836 (Adjusted R squared = .830)
Dependent variable: VCA

With respect to the contribution of each anatomical feature to the variation of the VCA, regression analysis of the 59 limbs in varus demonstrated CFB had greater correlation with the VCA than the NSA.

Table 3 demonstrates that CFB contributed to 52.8% of the variation in the VCA for the 59 limbs in varus alignment and this contribution was significant ($p < 0.05$). The NSA contributed to 2.4% of the variation in the VCA.

Table 3

Regression analysis for the valgus correction angle, bow and neck shaft angle

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.267	2.362		3.500	.001
	BOW	.528	.032	.916	16.402	.000
	NSA	-.024	.019	-.073	-1.309	.196

a. Dependent variable: VCA

DISCUSSION

Following TKR, postoperative limb alignment in the coronal plane has been reported to influence rate of revision of primary prostheses secondary to aseptic loosening, anterior knee pain and tibial plateau fracture. Postoperative malalignment has been reported as a major cause for generation of wear debris which cause inflammation resulting in aseptic loosening of components (10-13). Patella maltracking causes anterior knee pain and potentially fracture of the patella in patients who have undergone patella resurfacing (14). Aseptic loosening and anterior knee pain are among the top three causes for all component revision, the most expensive form of revision (21). The rate of tibial plateau fracture has also been reported to increase in patients with postoperative alignment outside prescribed limits. This may be explained by the observation of greater trabecular density in the anterior and central portions of the tibial plateau which decreases towards the periphery. Postoperative malalignment results in eccentric loading of the tibial plateau where the trabecular concentration and strength is reduced, increasing potentiating tibial plateau fractures (7-9). Given the technical demand, poorer patient satisfaction and cost, every effort should be made to mitigate revision of TKRs (21).

Femoral component positioning in the coronal plane is one determinant of postoperative whole lower limb alignment in the coronal plane and is influenced by accuracy of performance of the DFC. Given the reported accuracy of presumptive cuts varies in literature, preoperative whole lower limb radiographs can be used to accurately determine the VCA. Lack of consensus in literature regarding use of presumptive cuts may be due to variation between populations with respect to anatomical features influencing the relationship between the femur's anatomical and mechanical axes namely CFB and the NSA.

The study findings demonstrated a strong positive correlation between lateral CFB and the VCA similar to those of Mullaji *et al* (3). Thus as the magnitude of lateral CFB increases so does the VCA and vice versa (22).

Mullaji *et al* (3) studied the VCA in limbs with varus alignment given the correlation between varus alignment and lateral CFB. Similarly, there was a correlation between varus alignment of the limb and lateral CFB in the 59 varus limbs in this study. As the magnitude of varus limb alignment increases, the magnitude of CFB increases. Therefore given the demonstration of increasing magnitude of the VCA with increase in the magnitude of CFB, limbs with significant varus carry the risk of erroneous distal femur cuts if presumptive cuts are made and consequently malposition of the femoral component in the coronal plane. Mullaji *et al* (3) reported an average VCA of 7.3^0 (95% CI: 7.11^0 – 7.50^0). The VCA for the 59 lower limbs in varus alignment in this study was 6.51^0 (95% CI 6.02^0 – 7.00^0), significantly lower than that in the population studied by Mullaji *et al* (3). The VCA in the population studied by Kharwadkar *et al* (1) and Mullaji *et al* (3) averaged 5.40^0 (95% CI 5.21^0 - 5.59^0) also significantly different from the study population.

With respect to lateral bowing of the femur, this averaged 2.54^0 (1.68^0 – 3.40^0) in the 59 varus limbs and 3.29^0 – 3.91^0 in the varus limbs studied by Mullaji *et al* (3). The average lateral CFB was lower in the 59 varus lower limbs studied compared to that of the patients studied by Mullaji *et al* (3). The difference however was not significant as indicated by the overlap of the 95% confidence interval for the two populations. Given the demonstration of the difference in the VCA between patients with coxa vara and coxa valga when the 59 varus limbs were considered, racial differences reported in literature of relative coxa valga in Africans may partly explain the significant difference in the VCA between the varus limbs studied and those studied by Mullaji *et al* (3).

The proportion of limbs with valgus correction angles ≥ 9^0 in the respective studies was 0% in the study by Kharwadkar *et al*(1), 9.8% in the population sampled and 18.8% in the study by Mullaji *et al* (3). These limbs could potentially have inaccurate DFC performed if the most common presumptive VCA of 6^0 was used. Findingsin the population studied approximated those of and Teter *et al* (5) and Kinzel *et al* (23) who reported error rates of 10% and 8.5% respectively in the absence of use of preoperative imaging to accurately determine the VCA. They recommended preoperative imaging in routine TKR to determine the VCA.

CONCLUSIONS

Anatomical determinants of the relationship between the mechanical and anatomical axes of the distal femur vary between populations and can influence accuracy of performing presumptive DFC. The accuracy of cuts could affect positioning of the femoral component in the coronal plane which can determine postoperative alignment of the limb with implications for prosthesis survival. Presumptive cuts assume an ideal relationship between mechanical and anatomical axes of the distal femur and use a presumptive VCA of between 5^0 and 7^0, 6^0 being common. However, in populations with significant incidence of CFB this may be inaccurate in a proportion of patients, therefore, studies should be done to establish accuracy of presumptive cuts in all populations.

RECOMMENDATIONS

(i) Use of preoperative whole lower limb radiographs could increase the proportion of patients with an accurate VCA used for the DFC and consequently, accuracy of femoral component positioning. This could improve postoperative alignment in a greater proportion of patients reducing rate of revision secondary to improved survival. Preoperative radiographs are particularly important in patients with marked varus lower limb alignment on clinical assessment.

(ii) Facilities to perform whole lower limb radiographs are not widely available and use of presumptive cuts will continue for the foreseeable future. Given the demonstration of increase in CFB with increasing varus limb alignment and increase in the VCA with increasing CFB, surgeons should use the higher values in the range of VCA used to perform the presumptive DFC in patients with clinically evident varus lower limb alignment i.e., 7^0. There is however a caveat that this may be wide of the mark in a proportion of patients.

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