Full length article

Fixed distal femoral valgus cutting angle is still justifiable in total knee replacement

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ARTICLE INFO

Article history:

Received 16 January 2017

Available online 6 March 2017

Keywords:

Total knee arthroplasty

Computed tomography

Femoral valgus angle

Osteoarthritis

Pre-operative planning

ABSTRACT

Purpose: We undertook this study to determine whether it is justifiable to use a fixed femoral valgus angle in patients undergoing TKR.**Method:** 134 knees (59 females and 19 males) were studied by measuring their femoral valgus angle (FVA) on CT scan and the data was assessed statistically.**Result:** The average FVA was $5.83^\circ \pm 0.64$ (range – 4–7.5°). There was no statistically significant difference ($p > 0.05$) between the FVA between males and females and as per age.**Conclusion:** We conclude that it is justifiable to use a fixed femoral valgus cutting angle in the patients undergoing total knee replacement.

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1. Introduction

The restoration of the mechanical alignment of the limb in total knee replacement (TKR) has been shown to significantly reduce the incidence of loosening and improve the long term survival of the prosthesis.^{1–4} During surgery the alignment of the limb is restored by appropriately placed bone cuts augmented by soft tissue release. The neutral alignment of the limb can be achieved by perpendicular cuts made to the tibia and femoral mechanical axis. The resection of the tibia is done perpendicular to its anatomical axis which corresponds to the mechanical axis. On the femoral side, however, because the anatomical axis does not correspond to the mechanical axis and hence the cut has to be made at an angle which varies from patient to patient. The goal is to restore the mechanical axis of the limb within 3° of normal.^{5,6}

To achieve a cut perpendicular to the mechanical axis of the femur, one of the three options is available to surgeons. These include computer navigation, patient specific instrumentation and utilization of a fixed valgus angle in all patients. The gold standard for accurate femoral valgus angle is considered to be computer navigation but the cost and increased time duration associated

with its use is a major deterrent.⁷ The use of patient specific jigs is further associated with a marginal increased cost and delay in surgery for manufacturing of the custom jigs.⁸

The aim of this study is to determine the normal variability of the distal femoral valgus angle in the Indian population and to see whether it is justified to use a fixed femoral valgus angle. We also tried to find out the affect of age and sex on the femoral valgus angle in the Indian population.

2. Materials and methods

All patients of osteoarthritis presenting to our institution undergoing CT scans for pre-operative evaluation for patient specific instrumentation were included in the study between December 2015 to September 2016 and the data was assessed retrospectively. CT scanning was done using the PrePlan (StrykerTM, USA) protocol. One hundred and thirty four knees in 59 females and 19 males were included in the study. The knees were bilateral in 59 cases and unilateral in 16 cases. The average age of the patients was 63.84 years (range: 43–86 years).

3. Technique for angle calculation

All CT images included the hip, the knee and the ankle and the three dimensional reconstruction of each scan was done and key landmarks identified.

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Fig. 1. a Determination of Hip centre – Center of geometrical sphere which replicates the hip centre of femoral head. b Determination of femur centre at knee – Center of trochlear sulcus which is 5–10 mm anterior to Intercondylar notch roof.

3.1. Centre of femoral head

The centre of the femoral head is determined using the centre of the geometrical sphere which replicates the femoral head (Fig. 1a).

3.2. Centre of the knee

The centre of the knee on the other hand, corresponds to the trochlear sulcus which is 5–10 mm anterior to the roof of the intercondylar notch (Fig. 1b).

3.3. Mechanical and anatomical axes

The mechanical axis is defined as the line joining the centre of the femoral head and the centre of the knee joint (Fig. 2a) and the anatomical axis is the line joining the centre of the knee and the centre of the femoral shaft (Fig. 2b). The femur is then oriented in the coronal plane and angle between the mechanical and anatomical axes measured. (Fig. 3).

3.4. Femoral valgus angle

The distal femoral valgus angle (FVA) was defined as the angle between the anatomical and mechanical axes of the femur in the coronal plane.

4. Statistical analysis

The values of the FVA obtained were analyzed statistically using the SPSS software (version 12.0: SPSS, Chicago, IL). The data was subjected to Student's *t*-test and Pearson correlation coefficient to evaluate the statistical correlation between the genders, between the ages, and between the sides. *P* values <0.05 were considered statistically significant.

5. Results

The average FVA for the whole study population was 5.83° , with a range of 4° to 7.5° (Table 1). The average angle was 5.86° for the left side and 5.8° for the right side. The FVA for males was 5.81° and for females and 5.84° in males. There was no statistically significant difference ($p > 0.05$) between the FVA on the left and right side or between the males and females on either side (Table 2). There was positive correlation between the FVA on the left and right side for each patient ($R^2 = 0.752$; $P < 0.01$; Fig. 4) but no significant relationship between the FVA with the age of the patient (Fig. 5a, b).

The average femoral valgus angle in the present study was 5.83° . There was no statistically significant difference between the individuals with regard to sex. Moreover, there was no difference as far as other parameters like age and side was concerned.

6. Discussion

Total knee replacement aims at restoration of the mechanical axis of the patients. The first option is to use a fixed valgus angle of 5° or 6° as provided by commercially available cutting jigs.^{9,10} There may however be wide variations in the femoral anatomy that can significantly alter the FVA outside the acceptable margin.^{11,12} The variations include femoral bowing and changes in the neck

Fig. 2. a Determining the Femoral mechanical axis – Line joining to femur centre and hip centre called as femoral mechanical axis. b Determining Anatomical axis – Line joining through Femur centre and centre of femoral shaft.

Fig. 3. Determining valgus angle – Orient femur bone in coronal plane and measure the angle between femoral mechanical axis and anatomical axis.

shaft angle. These will affect the positioning of the femoral component and the overall mechanical axis of the limb, if commercially available fixed angle jigs are used.

The second option is to use customized valgus angles as determined by measurement of the individual femoral valgus angle on long leg radiographs before surgery. Several imaging errors may however occur with the use of x-rays to calculate the valgus angle such as extension deficits and rotational defects.^{13,14} Computer navigation is another option which can help in determining and matching a patient's original femoral valgus angle. However, the use of computer navigation on the other hand is quite cumbersome and has not been backed by enough

Table 1

Femoral valgus angle (FVA) data by gender and Side.

Parameter	n	FVA(°)	
		Average ^a	Range
Total no of Knee	134	5.83 ± 0.64	4–7.5
Male	19	5.81 ± 0.59	4.5–7
Female	56	5.84 ± 0.67	4–7.5
Left	68	5.86 ± 0.68	4–7.5
Right	66	5.8 ± 0.61	4.5–7
Male-left	19	5.84 ± 0.65	4.5–7
Male-right	15	5.77 ± 0.53	5–7
Female-left	49	5.87 ± 0.7	4–7.5
Female-right	51	5.81 ± 0.64	4.5–7

^a Average is expressed as mean ± SD.

Table 2

Statistical analysis of knee valgus angle (KVA) by gender and side.

Parameter	t	P-Value
Left/right	0.512	0.609
Male/female		
Right	0.287	0.775
Left	0.141	0.888

evidence.¹ There is additional cost associated with equipment procurement and also an associated learning curve.

The study was undertaken to determine whether it was justified to take a fixed femoral valgus in the osteoarthritic knees and hence avoid the use of custom valgus angles as determined using computer navigation and patient specific jigs.

The question regarding the use of fixed femoral valgus angles in distal femoral cuts has been under investigation with studies both in favor and against this. Deakin et al. in their analysis of 174 knees using the pre-operative radiograph, concluded that the FVA was statistically different between the males and females and advised against the use of fixed valgus resection angles.¹⁵ Bardakos et al. also reported a difference in the femoral valgus angle between the males and females.⁷ They explained that as the femoral offset increases, the femoral valgus angle increases. As males are supposed to have higher hip offset, they would have higher femoral valgus angles. Kharwadkar et al. measured the angle on the CT scout films of osteoarthritic knees and recommended the routine use of fixed femoral valgus angle.⁹

In all these studies, the angle measurements were done using long leg radiographs or CT scout films. The angle measurement in

Fig. 4. Correlation of the femoral valgus angle between the left and the right side.

Correlations between femoral valgus angle (Right) and Age

Correlations between femoral valgus angle (Left) and Age

Fig. 5. Correlation of the femoral valgus angle on the right and the left side with age.

these modalities has been shown to be affected by the positioning of the limb and also shown to have inter-observer variability.¹⁶ The present study is the first to our knowledge where the measurements of the angle were done on pre-operative virtual 3D reconstructed image of the proximal and the distal femur. Since the isolation of the various anatomic landmarks was done on a 3D image on a computer and by the protocol of the patient specific jigs, the chances of inter-observer variability were significantly reduced.

In the present study, we did not find any significant difference in the femoral valgus angle based on the sex. One possible explanation for the absence of a statistically significant difference in the femoral valgus angles between males and females is an average reduced height of the Indian subcontinent males as compared to their western counterparts. There was no statistically significant difference between the age and side of the patients.

The present study calculated the angle based on the proximal and distal femoral anatomical landmarks and did not take into consideration any affect of coronal or sagittal plane bowing. The effect of the femoral bowing on the distal femoral valgus angle is still under investigation and some reports have shown significant effect of femoral bowing on valgus angle.¹⁷

We conclude that the femoral valgus angle in the osteoarthritic population does not vary with the age and sex of the individual and hence we propose that a fixed valgus angle can be safely used.

Author contributions

RV – helped in the conceptualization of the study and helped in the preparation and review of the manuscript.

VV – was one of the principal investigators. He helped in the collection of data, statistical analysis, preparation and review of the manuscript.

EE – was one of the principal investigators. He helped in the collection of data, statistical analysis, preparation and review of the manuscript.

AKA – helped in the preparation and review of the manuscript.

Conflict of interest

Author A, Author B, Author C and Author D declare that they have no conflict of interest.

Funding

There is no funding source.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent

For this type of study formal consent is not required.

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