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Lower-limb alignment and posterior tibial slope in Pakistanis: a radiographic study

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ABSTRACT

Purpose. To assess the lower-limb alignment and posterior tibial slope in Pakistanis.

Methods. 40 male and 19 female healthy Pakistanis aged 20 to 45 years were recruited. A full weight-bearing anteroposterior radiograph of the entire lower limb of each subject was obtained. The axial alignment was measured based on the centres of the femoral head, knee, and ankle. The tibiofemoral (TF) angle, knee joint line obliquity angle (angle J), and posterior tibial slope were determined.

Results. The mean TF angle was more varus in men than women (178.4° vs. 180.0°, $p < 0.001$). The mean angle J was more medially inclined in men than women (93.4° vs. 91.4°, $p = 0.007$). The mean medial tibial slope was greater in women than men (16.0° vs. 12.5°, $p < 0.001$). The posterior tibial slope was greater in women than men (14.1° vs. 12.5°, $p = 0.02$), and was greater than the 5° to 10° commonly reported.

Conclusions. Knee alignment and geometry vary in different population subsets. With regard to total knee arthroplasty, the more medially inclined angle

J in Pakistani men suggests that an anteroposterior cut of the distal femur should be in increased external rotation, compared with Pakistani women. Whereas the greater posterior tibial slope in Pakistanis suggests that a proximal tibial cut with a greater posterior tibial slope may reduce the chance of tibial loosening and increase postoperative knee range of motion, especially when using posterior cruciate ligament-retaining designs.

Key words: arthroplasty, replacement, knee; knee joint

INTRODUCTION

It is important to achieve normal axial and rotational alignment in total knee arthroplasty (TKA). Computer navigation enables better alignments and improves outcomes.¹⁻³ Radiographic variation of normal lower-limb alignments in different subsets of populations has been reported.⁴⁻⁶ Absolute values cannot be recommended, as TKA should be individualised. We assessed the lower-limb alignment and the posterior tibial slope of 59 Pakistanis and compared these with those reported in Hsu et al.⁴ and Tang et al.⁶

MATERIALS AND METHODS

Between January 2004 and January 2007, 40 male and 19 female Pakistanis aged 20 to 45 years who had no history of pain, trauma, deformity or surgery of the hip, ankle or knee joints were recruited. A full weight-bearing anteroposterior radiograph of the entire lower limb (standing bare foot, knees in full extension, and patellae facing forward) of each subject was taken, with the X-ray beam centred on the knee at a distance of 2.5 m.

The axial alignment was measured based on the centres of the femoral head, knee, and ankle (Fig. 1). The femoral head centre was determined by Mose circles. The knee centre was determined by: (1) the centre of the subchondral medial tibial plateau, (2) the midpoint between the tips of the medial tibial spines, (3) the midpoint between the subchondral femoral condyles, and (4) the centre of the femoral intracondylar notch. The ankle centre was determined by: (1) the centre of the outer cortex between the 2 malleoli of the subchondral distal tibia, and (2) the centre of the subchondral talus. The mechanical axes of the femur and the tibia were the lines joining the centres of the femoral head and knee and the centres of the knee and ankle, respectively.

The anatomical axes of the femur were defined by the femoral shaft centres I and II. The former was located at the middle of the femoral shaft, whereas the latter was 10 cm proximal to the knee joint surface. The femoral anatomical axis I was drawn from the femoral shaft centre I to the knee centre, whereas the femoral anatomical axis II was drawn from the femoral shaft centre I to II. The latter followed the femoral medullary canal more closely. The transverse axis of the knee was a line tangential to the most distal points of the femoral condyles. The transverse axis of the ankle was inferred as the extension of the subchondral plate of the distal tibia.

The tibiofemoral (TF) angle was the medial angle formed by the mechanical axes of the femur and tibia. It indicates the overall alignment of the lower limb; a TF angle of $<180^\circ$ indicates varus alignment. Angle J (knee joint line obliquity angle) was the inferolateral angle formed by the transverse axis of the knee and the mechanical axis of the tibia. An angle J of $>90^\circ$ indicates a medial inclination of the knee joint. Angle A was the inferolateral angle formed by the transverse axis of the ankle and the mechanical axis of the tibia. Angles F1 and F2 were formed by the mechanical axis of the femur and femoral anatomical axes I and II, respectively.

A lateral radiograph of the knee joint incorporating the proximal two thirds of the tibia was taken with

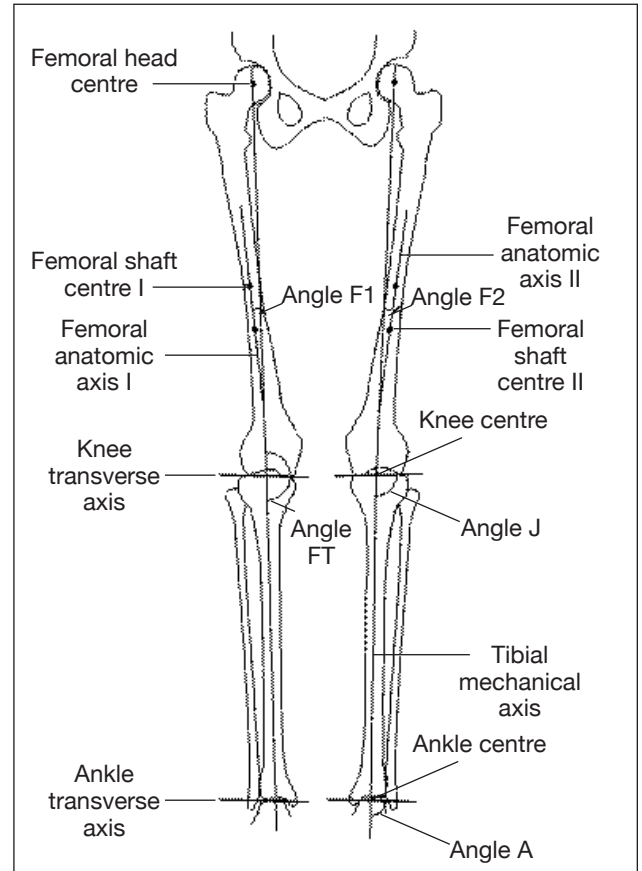


Figure 1 Axes and angles of the lower limb

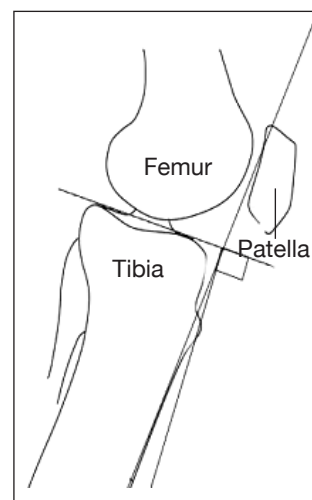


Figure 2 Measurement of the posterior tibial slope

exact superimposition of the femoral condyles. The posterior slope of the tibial plateau in relation to the anterior tibial cortex was determined by (1) the medial tibial plateau, (2) the lateral tibial plateau, and (3) the anterior tibial cortex line (representative of

Table 1
Comparison of axial alignments of the lower limb

Angle*	Mean±SD axial alignments of the right limb			Mean±SD axial alignments of the left limb			Mean±SD axial alignments of both limbs		
	Tang et al. ⁶	Present study	p Value	Tang et al. ⁶	Present study	p Value	Hsu et al. ⁴	Present study	p Value
Male									
TF	177.8°±2.5°	178.9°±2.7°	0.12	177.8°±2.9°	177.9°±2.8°	0.87	177.7°±2.3°	178.4°±2.8°	<0.001
J	94.7°±2.5°	93.3°±2.4°	0.04	95.0°±2.2°	93.5°±2.05°	0.01	91.0°±1.4°	93.4°±2.2°	<0.001
F2	5.6°±0.9°	5.4°±1.32°	0.53	5.7°±0.8°	5.4°±1.04°	0.24	-	-	-
F1	3.7°±0.9°	3.6°±1.09°	0.82	3.5°±0.8°	3.8°±1.08°	0.23	4.4°±1.7°	3.7°±1.1°	0.02
A	91.6°±3.3°	90.3°±1.81°	0.20	91.2°±3.1°	90.7°±2.4°	0.50	-	-	-
Female									
TF	178.1°±2.8°	180°±2.3°	0.02	177.5°±2.3°	180.1°±3.7°	0.13	178.7°±1.8°	180.0°±3.0°	0.04
J	95.3°±2.5°	91.4°±2.9°	<0.001	95.5°±2.5°	91.5°±3.6°	<0.001	90.1°±1.9°	91.4°±3.2°	0.05
F2	5.7°±1.0°	5.4°±1.3°	0.41	5.6°±1.1°	5.2°±0.7°	0.15	-	-	-
F1	3.3°±0.5°	3.2°±1.2°	0.51	3.0°±0.6°	2.7°±1.0°	0.32	3.6°±1.1°	2.9°±1.1°	0.02
A	90.7°±2.4°	91.7°±1.9°	0.18	90.9°±2.6°	90.5°±2.4°	0.59	-	-	-

* TF denotes tibiofemoral angle, J knee joint line obliquity angle, F2 & F1 angles between the mechanical axis of the femur and femoral anatomical axes II and I, respectively, and A inferolateral angle between the transverse axis of the ankle and the mechanical axis of the tibia

the extramedullary alignment guide for the proximal tibial cut). The posterior tibial slope was 90° minus the angle formed by the tibial plateau (averaging medial and lateral) and the anterior tibial cortex line (Fig. 2).⁷

All measurements were made by at least 2 authors. All variables were compared with paired (right and left) or unpaired (all others) *t*-tests.

RESULTS

The mean TF angle was more varus in men than women (178.4° vs. 180.0°, *p*<0.001, Table 1). The mean angle J was more medially inclined in men than women (93.4° vs. 91.4°, *p*=0.007, Table 1). The mean angle F1 was larger in men than women (3.7° vs. 2.9°, *p*=0.006, Table 1), which differed from that reported by Hsu et al.⁴ (3.3° vs. 4.0°, *p*=0.02). The mean angles F1 and A were not significantly different from those reported by Tang et al.⁶ The mean medial tibial slope was greater in women than men (16.0° vs. 12.5°, *p*<0.001, Table 2). The posterior tibial slope was greater in women than men (14.1° vs. 12.5°, *p*=0.02, Table 2), and was greater than the 5° to 10° commonly reported.^{8,9}

DISCUSSION

Normal lower-limb alignments vary among subsets of populations.^{4,10,11} In our study, the TF angle (overall alignment of the lower limb) was neutral (180.0°) in

Table 2
Posterior tibial slope in Pakistanis

Tibial plateau slope	Mean±SD slope		p value
	Male	Female	
Medial			
Right	12.8°±3.1°	15.5°±4.3°	0.008
Left	12.0°±4.2°	16.4°±2.9°	0.001
p Value	0.30	0.31	
Lateral			
Right	12.6°±2.7°	11.8°±5.0°	0.43
Left	11.3°±4.0°	12.1°±4.0°	0.48
p Value	0.34	0.71	
Medial (right and left)	12.5°±3.7°	16.0°±3.6°	<0.001
Lateral (right and left)	12.0°±3.1°	11.9°±4.5°	0.38
P Value	0.30	<0.001	
Combined medial and lateral (posterior tibial slope)	12.5°±3.7°	14.1°±4.5°	0.02

women but varus (178.4°) in men. Both Hsu et al.⁴ and Tang et al.⁶ reported varus alignment in men and women. Tang et al.⁶ reported more varus alignment in women than men in the Chinese. Varus alignment may be a contributing factor for osteoarthritis.¹²

Angle J is an index of obliquity of the knee joint. In our study, the knee joint was more medially inclined in men than women (93.4° vs. 91.4°). However, Hsu et al.⁴ and Tang et al.⁶ reported that women have a greater angle J than men. This should be considered when performing TKA in Pakistani men, as it suggests that an anteroposterior cut of the distal femur should be in increased external rotation to achieve a rectangular flexion gap.

The posterior tibial slope is important for flexion stability and range of motion. In our study, the posterior tibial slope was greater in women than men (14.1° vs. 12.5°), and was greater than the 5° to 10° commonly reported.^{8,9} The effect of the posterior tibial slope on subsidence or loosening of the tibial component, and postoperative range of motion and knee kinematics has been reported.¹³⁻¹⁷ Too great a posterior tibial slope exposes weak cancellous bone posteriorly. A proximal tibial cut perpendicular to the longitudinal axis of the tibia with 0° of posterior tibial slope increases the chance of tibial loosening, because of the weaker anterior tibial bone (particularly in patients with a greater anatomical posterior tibial slope). For posterior-stabilised designs, the posterior tibial slope is 0° or kept to a minimum to avoid flexion instability. However, for posterior cruciate ligament-retaining designs, the posterior tibial

slope is increased to facilitate the posterior femoral roll-back phenomenon. As people of Pakistani and Chinese descent have a greater posterior tibial slope, a proximal tibial cut with a greater posterior tibial slope may reduce the chance of tibial loosening and increase the postoperative knee range of motion, especially when using posterior cruciate ligament-retaining designs. Knee alignment and geometry vary in different subsets of populations. Further studies with a larger cohort may help improve the results of TKA.

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