DETERMINATION OF POSTERIOR TIBIA SLOPE AND SLOPE DETERIORATION WITH OSTEOARTHRITIS: A RADIOLOGICAL STUDY IN AN AFRICAN POPULATION

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ABSTRACT

Background: **The posterior inclination of the tibia plateaux relative to the longitudinal axis of the tibia is referred to as the Posterior Tibia Slope (PTS). Fore knowledge of the mean PTS in a given population is important in order to keep it as close to the normal range as possible during knee replacement. In various studies among the Caucasians, Asiatic or racial mixtures and using diverse methods the slope has been found to range in adults from 0 to 18 degrees. There is paucity of information regarding PTS in the indigenous African population.**

Objective: **This study was performed partly to determine the mean posterior slope in the African population and partly to study slope behaviour in arthritic degeneration.**

Design: **Investigational, case control study.**

Methods: **Two hundred twenty four X-ray films from 152 patients were used for the purpose of this study. Orthogonal radiographs for the full-limb including the knee were obtained using a standardized technique. The posterior tibia slope was obtained through measuring the angle between the tangent to the tibial plateau and the perpendicular direction to Tibial Shaft Anatomical Axis (TSAA).**

Results: **There were a total of 152 cases by the end of the study, 79 had non-arthritic knees (group 1) while 73 knees were osteoarthritic (group 2). Group 1 had a mean age of 48 years (95% CI 44.9 - 49.1 (2.1) and consisted of 37 males (47%) and 42 females (53%). Group 2 had a mean age of 53 years (95% CI 45.8- 50.2 (2.2) and consisted of 33 males (47%) and 40 females (53%). Control group had a mean slope angle of 6.8 compared to the arthritic group mean of 6.1 (95% confidence level $P < 0.05$) which was significant.**

Conclusion: **Our findings are that the mean posterior tibia slope among the African population is about 7°. We also conclude that the slope decreases with osteoarthritic degeneration. This would also suggest cruciate insufficiency that would result in either anterior or posterior tibia instability.**

INTRODUCTION

The posterior inclination of the tibia plateaux relative to the longitudinal axis of the tibia is referred to as the Posterior Tibia Slope (PTS). The posterior tibial slope plays a very important role in the kinematics and biomechanics of the knee joint. It has been shown that increasing PTS increases the tibial shear force and anterior tibial translation at the knee (1). This is particularly important in individuals undergoing proximal tibial osteotomy as these forces will accelerate degenerative changes. This altered PTS will affect not only the integrity of the cruciate ligaments but also the Range of Motion (ROM). Increased medial PTS has been reported to be associated with increased Anterior Cruciate Ligament (ACL) injuries due to increased anterior tibia translation (2, 3). Although some authors have reported increased stability of posterior cruciate ligament deficient knees with deepened posterior tibial slopes (4). Therefore, the slope should be maintained or corrected to maintain normal kinematics. These knee forces are highly significant in osteoarthritis and in the survival and function of knee arthroplasty; with potential complications, such as progressive loosening of implants, fractures of polyethylene inserts and wears (5, 6).

In degenerative joint disease, the slope and other aspects of the tibial plateaux are modified by bone and cartilage wear. The PTS will then measure the sum of these changes and may not reflect accurately the normal slope and mechanical axis of the knee (7). The slope is reported to deepen in osteoarthritis; meaning increased articular surface contact and increased tibial translation (8). Total knee replacement aims to restore the mechanical axis of the natural knee joint. This axis will be changed by an altered PTS; yet after replacement the PTS is expected to play a key role in crucial movements, particularly in achieving optimum knee flexion (9, 10).

In various studies using diverse methods, the slope has been found to range in adults from 0 to 18 degrees (11,12). Most of these studies are among the Caucasians, Asiatic or racial mixtures. The PTS in the African population has not been determined or documented. During knee arthroplasty we use tibia slope set elsewhere. This may influence our outcome adversely. The true PTS value for the African population requires to be established.

MATERIALS AND METHODS

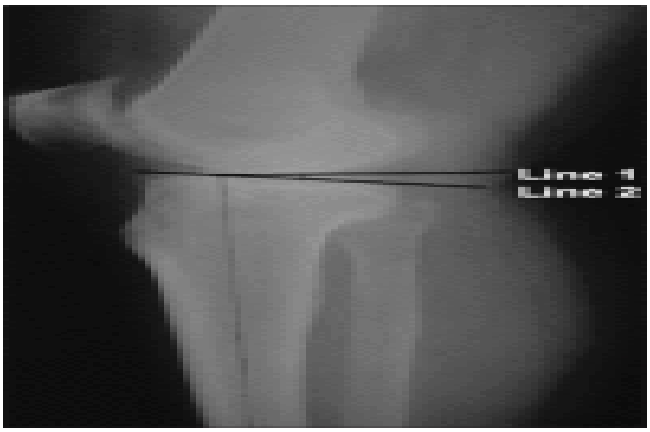
Measurements of posterior tibia slopes on knees in patients of African origin aged 40 years and above were conducted. These were patients requiring knee radiographs for various reasons, chiefly knee pain. Patients willingly consented for the use of their

radiographs for the study. Two hundred and twenty four films were examined from one hundred and fifty two patients. Radiographs of both knees were used when available and comparable; the mean value between the two was recorded. Orthogonal radiographs for the full-limb including the knee were obtained using a standardized technique.

A true lateral radiograph in extension with the exact superimposition of the femoral condyles was done in order to obtain various morphometric measurements. The radiograph was considered adequate if it exposed the knee and at least two thirds of the proximal tibia. The longitudinal axis of the tibia was obtained by manual goniometric positioning in order to draw the line marking the Tibial Shaft Anatomical Axis (TSAA). Another line was drawn tangentially over the center of the tibia plateaux joining the lowest points anteriorly and posteriorly. The angle between the tangent to the tibial plateau and the perpendicular direction to TSAA was measured. This angle was considered the posterior tibia slope (Figure 1). All the measurements were carried out solely by the author.

Figure 1

Shows how the PTS is determined. Line 1 is the perpendicular direction to TSAA while line 2 is drawn tangentially over the center of the tibia plateaux



The X-ray films done in the anteroposterior view was useful in grading of osteoarthritis. The patients were grouped into two; those with non-arthritic knees and those with overt osteoarthritis (Kellgren-Lawrence >2). The following patients were excluded from the study. All those found to have fractures, severe osteoporosis, tumours, Charcot's disease or osteolysis from any cause.

Statistical analysis: The results were analysed using the IBM SPSS statistics version 19 and computer generated statistics formulas. Statistical analysis included both descriptive and inferential measures. Mean values and standard deviations were calculated for standard valuables, and frequent counts and percentages were obtained for discrete valuables. All confidence intervals (designated CI) were at 95% confidence level. X^2 test was used for cross tabulation analysis. For continuous valuable (e.g. patient age), the 2 sample independent T test was used. The sample size was calculated at 90% power in order to demonstrate any effect between the slope in arthritic and non-arthritic knees.

RESULTS

The posterior tibial slope was obtained from 224 films from 152 patients. There were 70 males out of whom 33 (47%) had arthritic knees. There were 82 females out of whom 40 (49%) had arthritic knees (Table 1).

Table 1

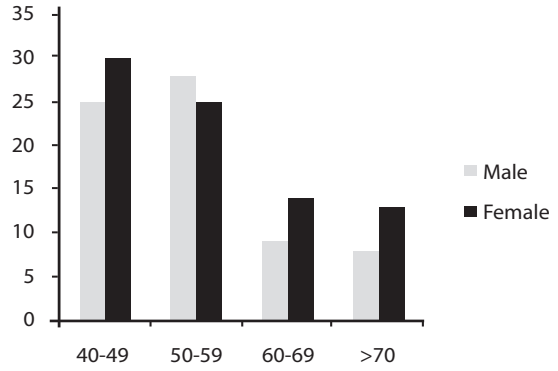
Sample distribution

Group	Male	Female	Total
Arthritic (Group 1)	33	40	73
Normal (Group 2)	37	42	79
Total	70	82	152

There was equal distribution of cases between age groups. Patients' age did not significantly differ between genders in both groups (P > 0.181). However, 71% of the patients were aged between 40 and 60 years (Table 2 and Figure 2).

Table 2 and Figure 2

Age distribution

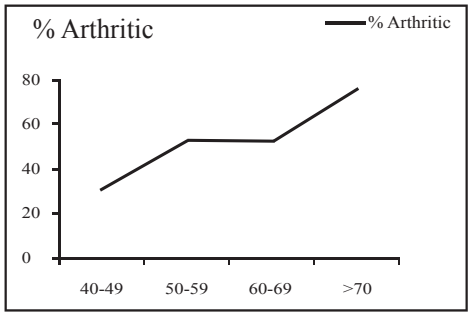


As expected there is exponential increase in osteoarthritis with age. Table 3 and Figure 3 confirm this expectation.

Age	Male	Female	Total	(%)
40-49	25	30	55	36
50-59	28	25	53	35
60-69	9	14	23	15
>70	8	13	21	14
Total	70	82	152	100

Table 3 and Figure 3
Age groups and arthritis

Age	Number	Normal	Arthritic	(%) Arthritic
40-49	55	38	17	31
50-59	53	25	28	53
60-69	23	11	12	52
>70	21	5	16	76
Total	152	79	73	48



The range for posterior tibia slope was found to be 3˚ to 15˚ (Table 4 and Figure 4). The graph is skewed to the left. The mean slope angle was found to be 6.6˚ (95% confidence limits of 6.2˚ to 7.0 ˚ (0.4 confidence interval). The arthritic group had a mean of 6.1˚ against control group mean of 6.8˚. This was found to be significant (P>0.0505). This showed deterioration of the slope by 0.7˚ (Table 5).

Table 4
Slope measurements

Slope	Normal knees	Arthritic knees	Total
3˚	3	4	7
4˚	7	8	15
5˚	19	16	35
6˚	14	21	35
7˚	14	12	26
8˚	6	1	7
9˚	3	5	8
10˚	3	2	5
11˚	2	2	4
12˚	3	1	4
13˚	0	0	0
14˚	5	2	7
Mean	79	73	152

Figure 4
Slope measurements

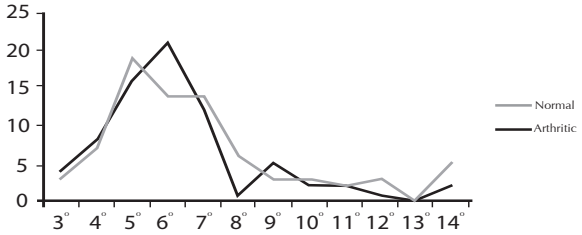


Table 5
Slope changes with arthritis

Means	Normal *m0*	Arthritic *m1*	Sample *m*	CI	S.e.d	SD	Z Score	P value
Male	6.7	6	6.6	0.67	0.81342	2.8	-0.861	0.1949
Female	6.4	6.1	6.2	0.40	0.398538	1.8	-0.753	0.2266
Sample	6.8	6.1	6.6	0.40	0.412151	2.5	-1.643	0.0505

DISCUSSION

The normal values for the posterior tibial plateau slope have not been fully mapped out for all populations. However, what is reported show a high variability between races and ranges from 0˚to 18˚.

The posterior tibial slope has been assessed using various methods, ranging from direct cadaveric measurements to CT scans and MRI. Various methods of assessment on plain radiographs have been described. Brazier *et al* (13) described the different anatomical axes against which the PTS could be measured. The lines included the Tibial Proximal Anatomical Axis (TPAA); Tibial Shaft Anatomical Axis (TSAA); Posterior Tibial Cortex (PTC); Anterior Tibial Cortex (ATC); Fibular Proximal Anatomical Axis (FPAA) and Fibular Shaft Axis (FSA). They concluded that among the proximal axes, the TPAA and PTC gave higher reliability. The ideal way to measure the PTS is against the anatomical axis of the tibia (TSAA). This will require a radiograph of the whole tibia which is usually not taken routinely in clinical practice. The Tibial Proximal Anatomical Axis (TPAA) does not exactly match the mechanical axis of the tibia but gives a close correlation. TSAA was used in this study.

Computer tomographic scan and MRI scan images have also been used for measuring the slope on medial and lateral sides separately (11,14). In a MRI study with separate measurement for medial and lateral plateaux slopes, the mean posterior slope was higher in the

lateral plateau than medial (11). In this study, we found the slope varied from 3˚-14˚ averaging 6.6˚. There was a higher slope in males than in females (mean of 6.6 vs 6.2). This is in contrast to the findings of Hashemi *et al* (11) who found slopes in females higher than males. Yoga and Suresh (8) found the mean preoperative posterior tibial plateau slope in Malaysian population to be 10.0°, 9.9° in Chinese and 8.8˚ in Indians , while Chiur *et al*(15), noted that the average posterior plateau slope in Chinese patients was 11.5°. Haddad *et al*(16), found mean PTS of 4.2˚ in Whites, 7.9 ˚ in Asians and 6.0 ˚ in Afro-Caribbean/European. This group found these racial differences to be statistically significant ($p < 0.001$). Didia (17) performed a radiological study on 212 lateral tibial radiographs measuring PTS with reference to the ATC found a mean PTS of 12.3°.

Some authors have reported a greater incidence of ACL rupture when the PTS angle is increased (18). Female athletes have been found to have a higher incidence of ACL injuries (up to nine times more common) (19,20) and also to be more susceptible to non-contact ACL injuries. Theoretically, therefore, increased PTS in certain populations might be associated with increased stress on the ACL. This increased strain or incompetence of the ACL will allow the tibia to sublux anteriorly. The effect is a reversal of the posterior slope which will then tend to flatten. A careful look at the knees during replacement surgery shows deepening concavities of the central part of the tibial condyle leaving the rim as protected by the meniscus almost intact.

However, as stated earlier, the slope has been reported to deepen in osteoarthritis; meaning increased articular surface contact and increased tibial translation (8). Chiur *et al* (15) also concluded that osteoarthritis increase the slope by two to three degrees. Our study shows that the slope flattens as osteoarthritis progresses (6.8 vs 6.1) with a p value=0.0505. Our patients were in all grades of arthritis from moderate to severe (Kellgren & Lawrence grade II-IV). Further studies with large samples dealing with end stage osteoarthritis (Kellgren & Lawrence grade IV) will perhaps, settle this matter.

CONCLUSIONS

Our findings are that the mean posterior tibia slope among the African population is 6˚. We also conclude that the slope decreases with osteoarthritic degeneration. This would also suggest cruciate degeneration and insufficiency that would result in either anterior or posterior tibia instability.

CLINICAL RELEVANCE

These results suggest that the PTS in the African is around 7°. This information is important during arthroplasty. Secondly, degenerative osteoarthritis affects tibia slope. A larger study is required to establish whether the slope increases or decreases. Lastly, it is important to maintain PTS during high tibial osteotomy; as again increase or decrease will affect long term stability.

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