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Article

Radiological assessment of the posterior tibial slope as a risk factor for osteoarthritis of the knee in Indian population

Dr. S K Saidapur[1], Dr. P. Sai Srinivas[2], Dr. Sarang Shete[3], Dr. Ajeet Hundekar [4,*] and Dr. R S Jatti[5]

1 Associate Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.
2 Post Graduate (JR), Department of Orthopaedics, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.
3 Assistant Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.
4 Assistant Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.
5 Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.
* Correspondence: ajeetortho@gmail.com

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Abstract: Background: Osteoarthritis (OA) is a chronic degenerative disorder that affects the joints, causing pain and stiffness. Its prevalence in India ranges from 22% to 39%. Considering the increasing life span and the burden it imposes on individuals and society, early detection or prediction of OA in high-risk groups is crucial for implementing preventive measures. Several risk factors, including weight, genetic factors, sex, previous traumas, occupational factors, physical activity, lifestyle, and age, are associated with osteoarthritis. The geometry of the articular surface may also play a significant role, especially in the sagittal plane. The posterior tibial slope (PTS), defined as the posterior inclination of the tibial plateau in relation to its longitudinal axis in the lateral view, is a determinant of altered joint biomechanics. However, there is a lack of studies examining the correlation between the PTS angle and the risk of knee osteoarthritis in the Indian population. This study aims to determine the value of, and confirm the association between changes in posterior tibial slope observed on radiographs and osteoarthritis.
Materials and Methods: After obtaining ethical approval, 153 individuals visiting the outpatient department were selected based on inclusion and exclusion criteria. Demographic parameters such as age, sex, weight, height, co-morbidities, and medications were recorded. Knee examination findings, pain assessment using the Visual Analog Scale (VAS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores were documented. Knee joint radiographs, including anteroposterior (AP) and lateral views, were examined for patients with early OA (Kellgren-Lawrence Grade I and II). The posterior tibial slope was measured by determining the angle between the tangent to the tibial plateau and the perpendicular direction to the Tibial Shaft Anatomical Axis (TSAA).
Results: The study included 153 individuals with early osteoarthritic knees (Grade I and II). The mean posterior tibial slope measured in our study was found to be 11.5 with a standard deviation of 1.34. The range of PTS in our study was between 7^o and 13^o.
Conclusion: Our study reveals that the posterior tibial slope in patients with early osteoarthritis was higher compared to the known normal values in the Indian population, suggesting an increased posterior tibial slope in individuals with osteoarthritic degeneration. Therefore, the posterior tibial slope can be used as a marker for screening osteoarthritis and initiating appropriate early interventions.

Keywords: Osteoarthritis (OA); Posterior tibial slope (PTS); Risk factors; Knee joint.

1. Introduction

Osteoarthritis is a condition that affects the joints, causing pain and stiffness. It is by far the most common form of joint disease, and the knee is one of the most commonly affected joints. The symptoms of osteoarthritis are pain, stiffness, a grating or grinding sensation (crepitus), swelling and the knee may either lock or give way on weight bearing. The geometry of an articular surface (e.g., posterior tibial slope), may be an important risk factor for development of knee osteoarthritis. The coronal alignment of the knee has been evaluated extensively, but there are only few studies for the sagittal plane alignment. The posterior inclination of the tibial plateau in relation to its longitudinal axis in lateral view is the Posterior Tibial Slope (PTS).

Posterior Tibial Slope is an important factor that influences the sagittal alignment, and is essential both for ligament function and knee kinematics. Hence, an altered posterior slope angle may play a role in knee joint kinematics and influence the risk of injury. Studies in oriental population in respect to PTS have found different values from that of Caucasians [1–5] An increase in Medial tibial slope may cause Anterior cruciate ligament strain and injuries. It is important to consider the posterior tibial slope as a potential risk factor for knee osteoarthritis, due to these abnormal biomechanics. We hypothesized that individuals with greater or lesser posterior tibial slope angles will have greater risk of developing knee osteoarthritis than those with a neutral posterior tibial slope. The study was performed to assess the correlation of posterior tibial slope as a risk factor for osteoarthritis, to determine the value of PTS in patients with early osteoarthritis in the Indian population and to establish whether changes (higher or lower) in the PTS, in comparison to known values in normal knees, are associated with Osteoarthritis.

2. Material and methods

This prospective observational study was done at our tertiary referral hospital between 1st January 2021 to 31st December 2021, after obtaining institutional ethical approval. A total of 153 patients were included in this study after obtaining informed consent as per inclusion and exclusion criteria.

Patients were first examined clinically thoroughly and then they were asked to get X Rays of the Knee joint in both PA and True Lateral views using a standardised technique [6,7] following which measurement of the Posterior Tibial Slope was done. PA view was taken to grade the level of osteoarthritis of the knee joint as per the Kellgren Lawrence classification [8], which is classified as Grade 0 (No discernible radiographic features of osteoarthritis present), Grade 1 ("Doubtful" joint space narrowing and possible osteophytic lipping), Grade 2 (Definite osteophyte(s) and possible joint space narrowing ("minimal") on AP weight-bearing radiograph), Grade 3 (Multiple osteophytes, definite JSN ("moderate"), sclerosis, minimal bony deformity) and Grade 4 ("severe") (Large osteophytes, marked joint space narrowing, severe sclerosis and definite bony deformity disturbing the bony contour or joint alignment). For PA view, the source is kept at a distance of 1.8 m with beam tilted 10^0 caudally. In the PA view, superposition of the posterior and anterior edges of the tibial plateau is required to accurately demonstrate the joint space. If the edge of the tibial plateau nearly touches or overlaps the distal femoral condyle on either knee, it becomes unacceptable (Figure 1).

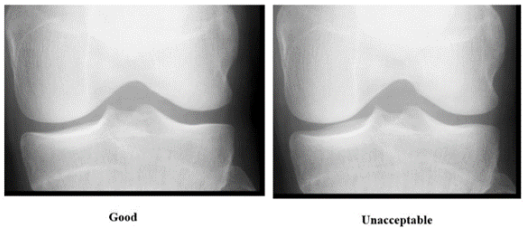

Figure 1. Acceptable PA view of the knee joint.

The lateral view of the affected knee was used for the measurement of PTS. The radiologically acceptable lateral view of knee should have a clearly visible front of patella, tibial tuberosity, and top of patella with edges of all bone seen without bright light and front of femoral condyles overlie each other (Figure 2).

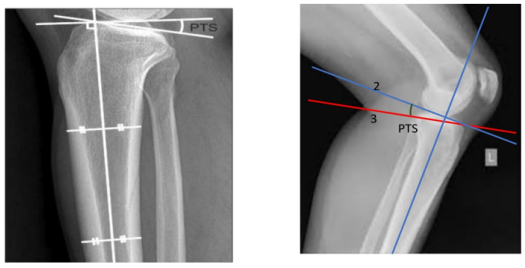

Figure 3. Measurement of the Posterior Tibial Slope

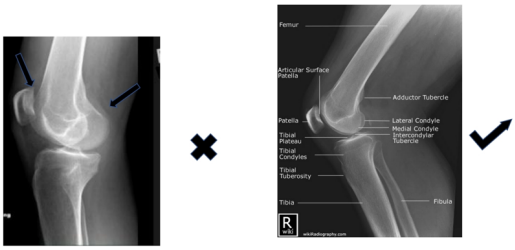

Figure 2. Incorrect and correct way to obtain Lateral Knee radiographs

Posterior tibial slope (Figure 3) is defined as the angle formed by two lines in the lateral knee radiograph. The first line is the line perpendicular to the anatomical axis of the tibia. The second line is formed by joining the most proximal points on the tibia plateau on the lateral radiograph as defined by Massin et al. [9] avoiding osteophytes. Although there was no previous consensus on the ideal anatomical axis to measure PTS, the proximal anatomical axis, that is the line connecting midpoints of outer cortical diameter at 5 and 15 cm distal to the knee joint, is now recommended because it is most parallel to the sagittal mechanical axis [10]. This axis was assumed to be the anatomical axis in our study also.

The study includes patients over the age of 30 years with complaints of knee pain along with early osteoarthritic changes radiologically, and gave their wilful consent to participate in the study. The study excluded patients with fractures around knee and tibia, ligamentous injury of knee, severe osteoporosis, tumours, skeletally immature knees and advanced Osteoarthritis of the knee. The reports of all said investigations were then documented, compiled and analysed. All the observations and measurements of PTS were statistically analysed using SPSS.

3. Results

There were 153 patients with knee osteoarthritis (grade I & II) as part of the study. The analysis of age distribution among our study group shows that, the age group 50-60 years are more affected with arthritis with mean age of 53.92 years (Figure 4).

AGE	NUMBER	%
30 - 40	3	1.96
40 - 50	43	28.10
50 - 60	84	54.90
60 - 70	21	13.73
70 - 80	2	1.31
TOTAL	153	100.00

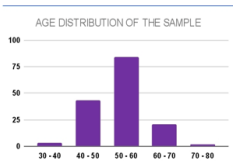

Figure 4. Age wise distribution of osteoarthritis in male and female

The Sex distribution in our study reveals there is a slightly increased prevalence of arthritis among female population, with 92 females and 61 males as part of our study (Figure 5).

GENDER	NUMBER	%
FEMALE	92	60.13
MALE	61	39.87
TOTAL	153	100.00

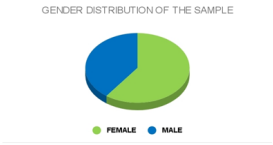

Figure 5. Gender wise distribution of osteoarthritis

The mean posterior tibial slope measured in our study was found to be 11.5 with a standard deviation of 1.34. The range of PTS in our study was found to be between 7^o - 13^o (Figure 6)

PTS	NUMBER	%
7 - 8	12	7.84
8 - 9	16	10.46
9- 10	21	13.73
10 - 11	33	21.57
11 -12	52	33.99
12 -13	19	12.42
TOTAL	153	100.00

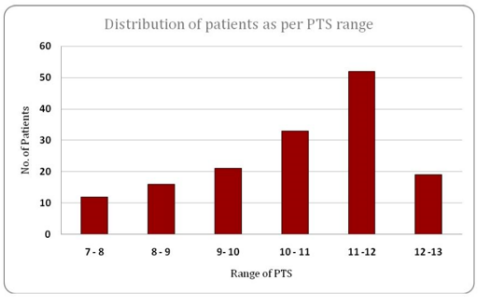

Figure 6. Distribution of patients as per PTS range

4. Discussion

The PTS has been assessed using various methods ranging from direct cadaveric measurements to X-rays, computed tomography (CT), and magnetic resonance imaging (MRI) scans. The ideal way to measure the PTS by X-ray is against the anatomical axis of tibia. Both CT and MRI are useful in measuring the medial and lateral slopes separately [11,12]. The age and gender-specific PTS have not been fully mapped out for all populations. PTS in normal knees has found to be different in different studies, with variations depending on factors like age, gender, ethnicity as well as the methods and modalities used for measurements. In a study done by V. Thirunarayan et al. (2020) [13], they have measured PTS of normal knees with values of 9.690. Chiu et al. [1] also has measured PTS of both Normal and osteoarthritic knees with values for the normal knees being 10.80. Studies done on normal knees by Yoo et al. [12] gave values of 10.6 while Yoga et al.[6] gave values of 10.1. Didia et al. [14] had done a study on normal knees with values of PTS as 12.3. The highest values for Asians have been shown as 13.65 by the study done by Khattak et al. [9].

Many studies in osteoarthritic knees have also shown contrasting results i.e., while some have shown the slope to increase with osteoarthritic degeneration, others have shown that it decreases. Matsuda et al. (1999) [3] evaluated the posterior tibial slope in 30 normal and 30 varus knees using magnetic resonance imaging in one of the earliest studies on PTS. The mean tibial posterior slope in the medial plateau was 10.7 degrees in the normal knees and 9.9 degrees in the varus knees. The mean tibial posterior slope in the lateral plateau was 7.2 degrees in the normal knees and 6 degrees in the varus knees. JM Muthuuri et al. (2014) [15] conducted a study in an African population. They found that the mean posterior tibial slope among the African population is about 7^o. The control group had a mean of 6.8^o while the arthritic group had a mean of 6.1^o. This study has concluded that the slope decreases with Osteoarthritic degeneration.

Similarly, the increase in PTS with osteoarthritic degeneration has been shown in many studies. Chiu et al., (2000) [1] studied the posterior tibial slope of Chinese cadaveric tibia. They measured posterior slope of lateral tibial plateau of both Normal and osteoarthritic knees with values of 10.80 and 13.10 respectively and concluded that osteoarthritis increases the slope by two to three degrees. Dehghan M et al., (2014) [16] in

their study examined the posterior tibial slope in two groups with knee osteoarthritis and healthy knee; they reported that PTS values in patients with osteoarthritis were significantly higher than in healthy subjects. But their study is based on entirely different groups, the diseased and healthy ones.

The research studies in oriental population in respect to PTS have found different values though, from that of Caucasians. Further studies were hence required to understand the variations among Indian populations. Qidwai et al., (2019) [17] conducted a study on patients with relation to the habit if squatting, and was aimed at the measuring PTS in the north Indian population. The mean values were found to be 10.74^o, with those of non-squatters found to be 9.25. Here, the posterior tibial cortex was used as a reference line to measure the PTS. A study done by V Thirunarayan et al., (2020) [13] found the mean PTS in normal knees to be 9.69. Here the TPAA was used as the reference axis. Kumar P et al., (2022) [18] conducted a study on patients with healthy knees, with mean values of PTS of medial and lateral slope being 8.60 and 7.94 respectively.

Mohanty SS et al., (2013) [19] conducted a study in the Indian population using X-Rays where the PTS was measured using tibial anatomical axis as reference line. The study was done on patients with Ahlback grade 4 and 5 osteoarthrosis of knee and PTS was found to have a mean value of 11.64. Medda S et al., (2017) [5] in their study to estimate the posterior tibial slope in the adult Eastern Indian population, found the mean values to be 13.6^o with subjects including those with normal and osteoarthritic knees. Nekkanti S et al., (2018) [20] studied the posterior tibial slope in the South Indian population where the subjects included were patients with minor knee injuries, but importantly excluded those with advanced OA. It was found to have a mean value of 10.37^o.

In our study, we have measured PTS of osteoarthritic knees with values of 11.5^o with a range of 7^o to 13^o. Our study also confirms that PTS increases with osteoarthritic degeneration, upon comparison with known values from previous studies. In our study, we have not included post-TKR patients, so the actual clinical significance of PTS, with respect to post TKR, has not been done in our study. As per Yoga et al. (2009) [6] who have studied the preoperative and postoperative TKR PTS, they have suggested that patients with higher preoperative PTS end up with higher postoperative PTS, which may increase the range of flexion, but these patients may not achieve full extension, which is not desirable. They also suggest that in patients with high preoperative PTS, when tibial cut is parallel to the surface, it exhibits 40% greater load-carrying capacity and 70% greater stiffness than paired tibiae cut perpendicular to long axis. In this condition, to achieve full range of extension, an excess resection of proximal tibia needs to be taken.

Our study had certain limitations like the small sample size, and medial and lateral tibial slope vary in same patients. Computed tomography is the most accurate method in measuring PTS and is preferred over X-rays while the clinical significance of PTS in TKR was also not assessed.

5. Conclusion

Our study finds that the posterior tibial slope in patients with early osteoarthritis was higher in comparison to known values among patients with normal knees in the Indian population, suggestive of increased posterior tibial slope in individuals having osteoarthritic degeneration. Hence, the posterior tibial slope can be used as a marker for screening of osteoarthritis, and can be used to initiate early interventions.

Further studies are required with more samples to validate PTS as an arthritic marker and its statistical significance in terms of sensitivity and specificity, to study gender- and age-related changes of PTS and its statistical significance to study the slope changes with progression of arthritis, and to further evaluate the significance of PTS with respect to TKR.

Author Contributions: All authors contributed equally to the writing of this paper. All authors read and approved the final manuscript.

Conflicts of Interest: Authors declare no conflict of interests.

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