

**RESEARCH ARTICLE**

# Measurement of Posterior Tibial Slope Using Magnetic Resonance Imaging

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*Research performed at Imam Reza (AS) Hospital in Mashhad, Mashhad, Iran**Received: 10 December 2016**Accepted: 09 March 2017***Abstract**

**Background:** Posterior tibial slope (PTS) is an important factor in the knee joint biomechanics and one of the bone features, which affects knee joint stability. Posterior tibial slope has impact on flexion gap, knee joint stability and posterior femoral rollback that are related to wide range of knee motion. During high tibial osteotomy and total knee arthroplasty (TKA) surgery, proper retaining the mechanical and anatomical axis is important. The aim of this study was to evaluate the value of posterior tibial slope in medial and lateral compartments of tibial plateau and to assess the relationship among the slope with age, gender and other variables of tibial plateau surface.

**Methods:** This descriptive study was conducted on 132 healthy knees (80 males and 52 females) with a mean age of  $38.26 \pm 11.45$  (20-60 years) at Imam Reza hospital in Mashhad, Iran. All patients, selected and enrolled for MRI in this study, were admitted for knee pain with uncertain clinical history. According to initial physical knee examinations the study subjects were reported healthy.

**Results:** The mean posterior tibial slope was  $7.78 \pm 2.48$  degrees in the medial compartment and  $6.85 \pm 2.24$  degrees in lateral compartment. No significant correlation was found between age and gender with posterior tibial slope ( $P \geq 0.05$ ), but there was significant relationship among PTS with mediolateral width, plateau area and medial plateau.

**Conclusion:** Comparison of different studies revealed that the PTS value in our study is different from other communities, which can be associated with genetic and racial factors. The results of our study are useful to PTS reconstruction in surgeries.

**Keywords:** Plateau, Posterior tibial slope, Tibia, Total knee arthroplasty

**Introduction**

Majority of daily living activities is based on lower limbs. The importance of leg as the most distal part of the body is very clear. It plays a major role in weight bearing, absorbing and adjusting pressures and exerted blows during walking, running, jumping and maintaining the position, whether standing or moving (1). Orthopedic surgeries are often performed with the aim of returning anatomy of the organ or bone to its normal status. Maintaining the lower limb angles and axes is very critical in surgeries on lower extremity reconstruction such as surrounding the knee. Knowing

these angles are essential, especially for knee osteotomy and total knee arthroplasty (TKA), since one of the major factors of success for such surgery with increased longevity of knee joint replacement is to maintain normal axis of the lower limb (2, 3). Tibial slope is an important factor in weight bearing and implant design (4, 5). Posterior tibial slope (PTS) is actually the slope of tibial plateau normally from anterior to posterior relative to its longitudinal axis (6). It is a key parameter in the knee joint biomechanics, and leads to anterior-posterior stability of the knee (7, 8).

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Posterior tibial slope (PTS) affects knee joint stability, ACL ligament, flexion gap and posterior femoral rollback that are associated with wide range of knee motion (9).

To the best of our knowledge, previous studies have examined only the PTS value in Iranian population and relationship of this angle with age and gender. In this study, we focused on posterior tibial slope in Iranian adults to investigate its association with other variables of tibial plateau surface. Finally obtained results were compared with the outcomes of similar studies conducted in other countries.

### Materials and Methods

Research methodology due to the nature of subject is a descriptive study that was conducted from January to September 2015 on 132 knees including 80 males (61%) and 52 females (39%) at Imam Reza (AS) Hospital in Mashhad, Iran. Ethics Committee of Shahid Beheshti University of Medical Sciences approved the proposal. Informed consent was obtained from all patients.

All patients admitted to the hospital clinic due to complaints of knee problems who were needed to knee MRI based on scientific indications. Then after obtaining history and physical examination by specialists, the patient who had no problems in terms of bone and soft tissue examinations were included in the study.

Exclusion criteria were history of advanced arthrosis and rheumatoid arthritis, previous fracture in the proximal tibial, congenital anatomy or deformity gross and lower extremity length discrepancy.

To measure the PTS angle, first line was drawn tangential to posterior tibial cortex, and the other perpendicular to the first line. A third line was drawn tangential to the surface of the tibial plateau. The angle between the third and the second lines was considered as posterior tibial slope, Figure 1 (10).

A fixed cut was elected to measure posterior tibial slope in the middle of medial and lateral compartments to avoid measurement errors and to perform all measurements in a certain cut.

In this study, proximal tibial dimensions were measured which included anteroposterior length (AP), mediolateral width (ML), medial anteroposterior length (MAP), lateral anteroposterior length (LAP), tibial plateau area, medial and lateral tibial plateau areas, complete bounding box area (the smallest quadrilateral surrounding tibial plateau), medial bonding box and lateral bonding box areas, Figure 2. Finally, the relationship between morphological data obtained from these variables and the degrees of tibial plateau slope was evaluated.

### Results

In this study, 132 knees were studied. The mean age of patients was  $38.26 \pm 11.45$  with a range of 20-60 years. The mean posterior tibial slope was  $7.78 \pm 2.48$  degrees in the medial compartment and  $6.85 \pm 2.24$  degrees in lateral compartment. In addition, the mean angle (degree) in medial and lateral compartments was respectively  $8.08 \pm 2.35$  and  $6.48 \pm 1.98$  in females and  $7.58 \pm 2.53$  and  $7.09 \pm 2.37$  in males.

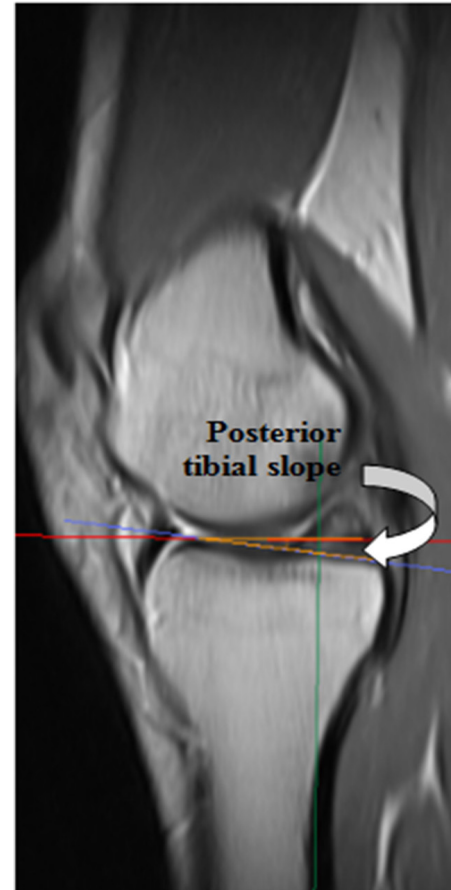


Figure 1. An example of measuring anterior - posterior slope of tibial plateau.

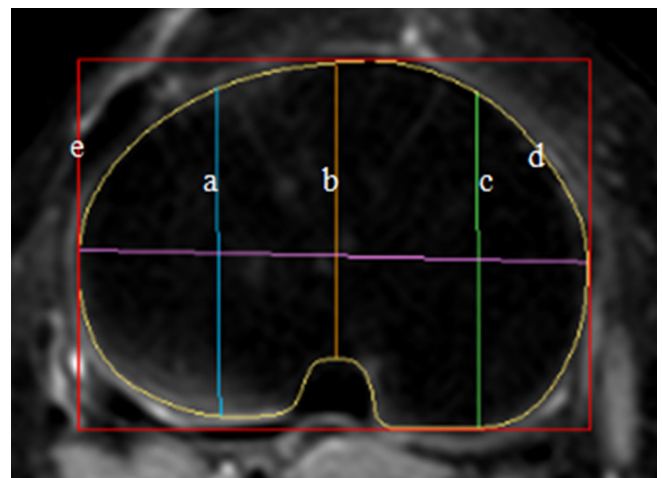


Figure 2. Axial MRI image of the proximal tibia showing (a) the lateral anteroposterior length (LAP), (b) the anteroposterior length (AP), (c) the medial anteroposterior length (MAP), (d) the plateau area, and (e) the bounding box area.

Maximum and minimum PTS angle measured in these patients were respectively 13.9 and 2.4 degrees in the medial compartment, with 15.0 and 2.6 degrees in the lateral compartment.

Categories of individuals in terms of percentage of various degrees of tibial plateau slope in the medial and lateral compartments are shown in Figures 3 and 4.

Also, the number of males and females in terms of slope with less or more than 10 degrees in the medial and lateral compartments has been determined [Table 1].

**Discussion**

The importance of determining the angle and direction is clear economically and scientifically. It is mainly because of the increasing number of knee reconstruction surgeries, particularly knee joint replacement, and the important role of maintaining normal lower limb angles in the longevity of the joints (11-13).

Concerns for impact of PTS on knee joint loading resulted in the development of surgical techniques to precisely PTS control during surgery (14). Usually, it is tried to maintain posterior tibial slope as much as possible in knee anatomical conditions during TKA surgery to enhance knee flexion (15). In the current study, the mean posterior tibial slope was  $7.78 \pm 2.48$  degrees in the medial compartment and  $6.85 \pm 2.24$  degrees in lateral compartment. Comparison of different studies revealed that the PTS value in our study is different from other communities.

Moore et al. reported the slope value of  $14 \pm 3.7^\circ$  (range:  $7-22^\circ$ ) in 50 Americans (16). Matsuda et al. obtained this value about  $10.7^\circ$  (range:  $5-15.5^\circ$ ) in 30 Japanese patients, and Chiu et al. found the mean slope of  $14.7 \pm 3.7^\circ$  (range:  $5-22^\circ$ ) in 25 Chinese cases (17, 18).

In a study by Hosseinzadeh et al. conducted in Iran, the slope value was  $9.4 \pm 1.8^\circ$  (range:  $2-18^\circ$ ) in 108 knees.

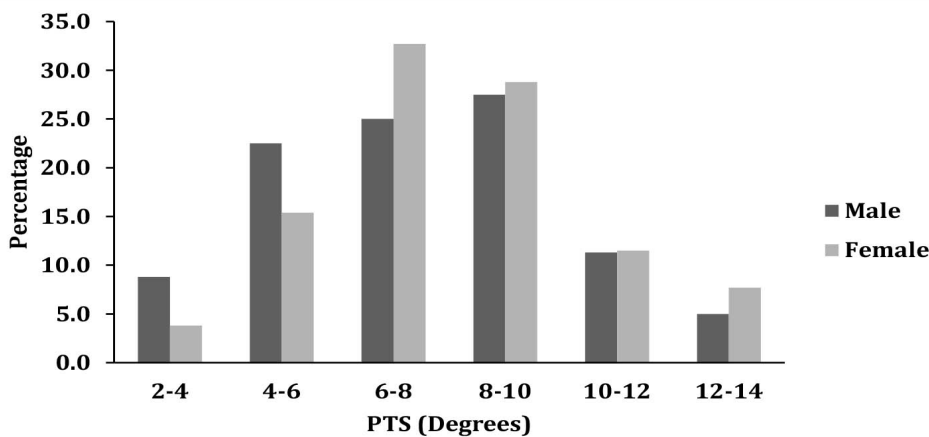


Figure 3. Percentage of different tibial plateau slope for both sexes in medial compartment.

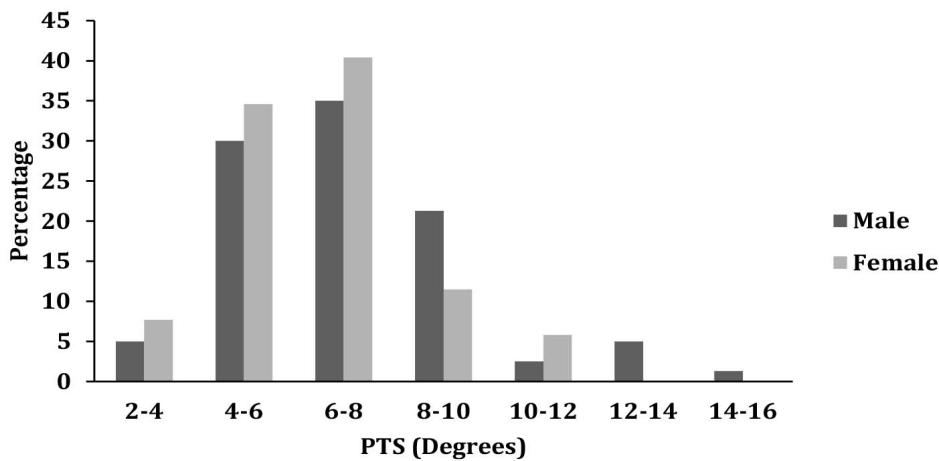


Figure 4. Percentage of different tibial plateau slope for both sexes in lateral compartment.

**Table 1. Number of male and female study subjects in terms of tibial plateau slope with less or more than 10 degrees in medial and lateral compartments**

	Gender	Slope < 10°	Slope ≥ 10°
Medial compartment	Male	67	13
	Female	42	10
Lateral compartment	Male	72	8
	Female	49	3

In another study by Qureyshi et al., the slope value was reported  $9.3 \pm 1.4^\circ$  (range:  $1-19^\circ$ ) in 431 knees (19, 20).

The reason for differences in the values of posterior tibial slope between our study and other studies carried out in Iran could be due to differences in individual heights and imaging technique.

The results indicate that the values of posterior tibial slope in Iranian society are larger different compared to other societies, especially Western societies, and smaller than other ethnic groups.

In this study, the relationship among the values of posterior tibial slope with age and gender were examined, which no significant correlation was found between these two factors and PTS ( $P \geq 0.05$ ). The results are in agreement with other studies conducted in Iran (19, 20).

Comparison of PTS with dimensions of other tibial variables revealed significant relationship between posterior tibial slope and variables of plateau, ML and medial plateau. Thus, in the medial compartment, the posterior tibial slope decreases a degree per each mm increase in ML, and the posterior tibial slope decreases 2.9 degrees per square millimeter ( $\text{mm}^2$ ) elevation in medial plateau. This rise is 5.3 degrees per each square millimeter increase in plateau in the medial compartment, and 3.9 degrees in the lateral compartment.

Some assumptions stated that anatomic factors, including PTS value, are considered as contributing factors in osteoarthritis (21-23). Dehghan and Bahmani 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 (24).

In an in vitro study, Garg and Walke observed significant improvement in motion in PTS with 10 degrees (25). In contrast, other studies have shown that increased posterior slope cannot improve the motion and can cause anterior displacement and thus increase the load on anterior cruciate ligament. This increased load in turn would be a predisposing factor for ACL rupture (26).

Moreover, excessive PTS may lead to abnormal anterior tibial translation and instability in posterior and anterior cam-post, which can lead to an increase in molecular weight of polyethylene coating and biomechanical changes that eventually can reduce the TKA survival (27, 28).

PTS angle changes also affect the relationship between patellar bone and patellar tendon. Kaper et al. showed that changes in PTS might cause patella baja (29). Therefore, PTS in the upper tibial cutting in TKA surgery is considered as an important factor in postoperative

knee joint biomechanics and clinical outcome (15).

The results revealed the difference of posterior tibial slope in Iranian population compared to other communities. Thus, more detailed studies to investigate the cause of the mentioned difference and computation of real slope values of the Iranian population is required.

These changes might be due to differences in race and genetic factors. Moreover, difference of Iranian's lifestyle compared to other nations including sitting on the ground, way of worship and specific shape of toilets could be considered as effective factors (19).

Due to the significance of PTS, retaining normal knee slope is important during arthroplasty and high tibial osteotomy (14, 30, 31). Results and data obtained from this study can be used in PTS reconstruction in knee surgery.

Given the ethnic distribution in Iran and the importance of anatomical and morphological indicators, this study is proposed to be carried out more widely in other regions. We did not calculate two variables of height and weight in the patients as independent factors. Therefore, future studies should consider these parameters.

Authors report no conflict of interest.

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