Measurement of posterior tibial slope using magnetic resonance imaging

Abstract

Background: Posterior tibial slope (PTS) is an important factor in the knee joint biomechanics and one of the bone features, which leads to knee joint stability. Posterior tibial slope affects 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.

Materials and methods: This descriptive study was conducted on 132 healthy knees (80 males and 52 females) with a mean age of 38.26±11.45 (20-60 years) at a medical center in Mashhad, Iran. All patients required to MRI admitted for knee pain with uncertain clinical history and physical examination that were reported healthy at knee examination were enrolled in the study.

Results: The mean posterior tibial slope was 7.78±2.48 degrees in the medial compartment and 6.85±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.

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

Keywords: Tibia, Posterior Tibial Slope, Total Knee Arthroplasty, Plateau

Introduction

The base of all activities of daily living is lower limbs. The importance of leg as the most distal part of the body is not hidden from anyone, which plays a major role in weight-bearing, absorbing and adjusting pressures and exerted blows when walking, running, jumping and

maintaining the position, whether standing or moving (1). Orthopedic surgeries are performed often with the aim of returning anatomy of the organ or bone to normal status. Maintaining the lower limb angles and axes is very important 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), because one of the major factors of success in the surgery and increased longevity of knee joint replacement is to maintain normal axis of the lower limb (2, 3). We believe that the 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), which is a key parameter in the knee joint biomechanics, and leads to anterior-posterior stability of the knee (7, 8).

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 have decided to obtain posterior tibial slope in Iranian adults, investigate its association with other variables of tibial plateau surface, and finally compare the obtained results with studies 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.

Before doing so, Ethics Committee of Shahid Beheshti University approved the proposal provided, and 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, despite getting history and physical examination by specialists, and had no problems in terms of bone and soft tissue examinations and had a healthy knee in examinations were included in the study, after confirming the health of knees by the radiologist.

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.

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

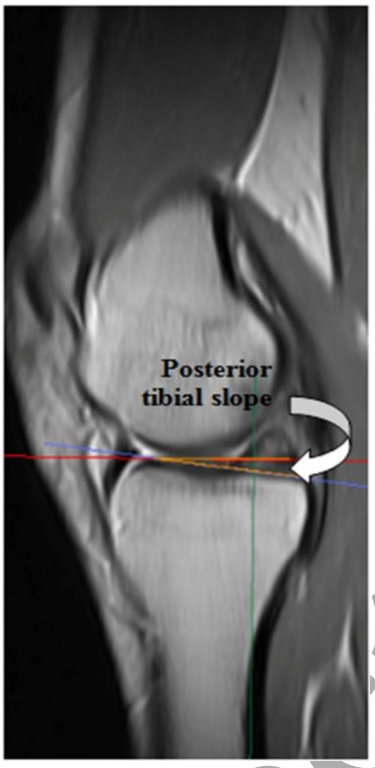

Fig 1- An example of measuring anterior - posterior slope of tibial plateau

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, including: anteroposterior length (AP), mediolateral width (ML), medial anteroposterior length (MAP), lateral anteroposterior length (LAP), an tibial plateau area thoroughly, as well as medial and lateral tibial plateau areas, bounding box area (the smallest quadrilateral surrounding tibial plateau) completely, and also 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.

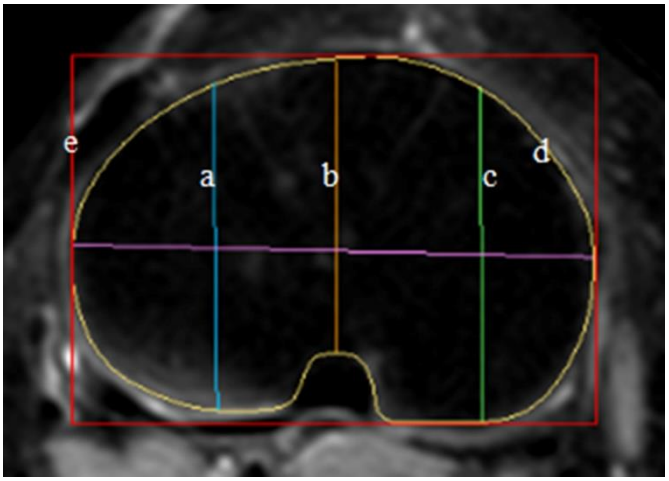

Fig 2- Axial MRI image of the proximal tibia showing (a) the lateral anteroposterior length (LAP), (b) the anteroposterior length(AP), (c) the medial anteroposterior length(MAP), (d) the Plateau area, (e) the Bounding box area

Results

In this study, 132 knees were studied; the mean age of patients was 38.26±11.45years (20-60 years).

The mean posterior tibial slope was 7.78±2.48 degrees in the medial compartment and 6.85±2.24 degrees in lateral compartment. In addition, the mean angle (degree) in medial and lateral compartments was respectively 8.08 ± 2.35 and 6.48 ± 1.98 in females and 7.58 ± 2.53 and 7.09 ± 2.37 in males.

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

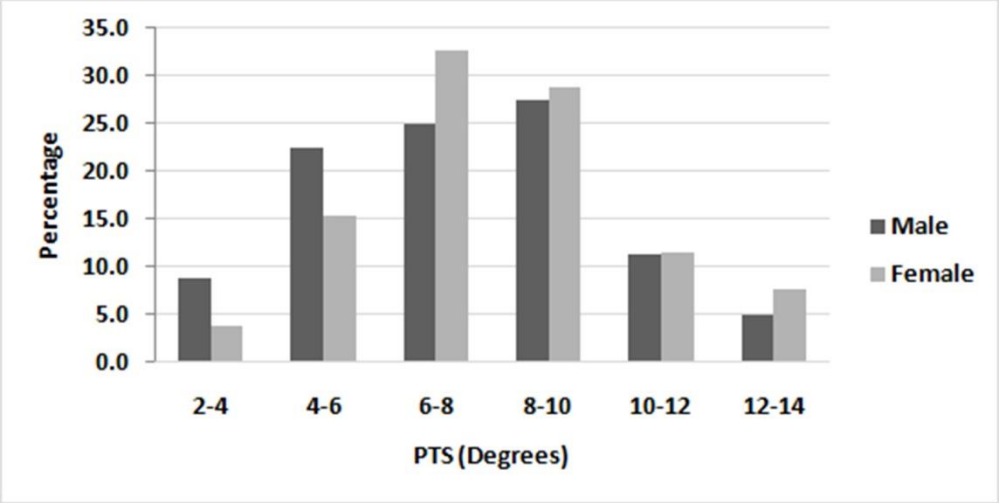

Fig 3- Percentage of different tibial plateau slope for both sexes in medial compartment

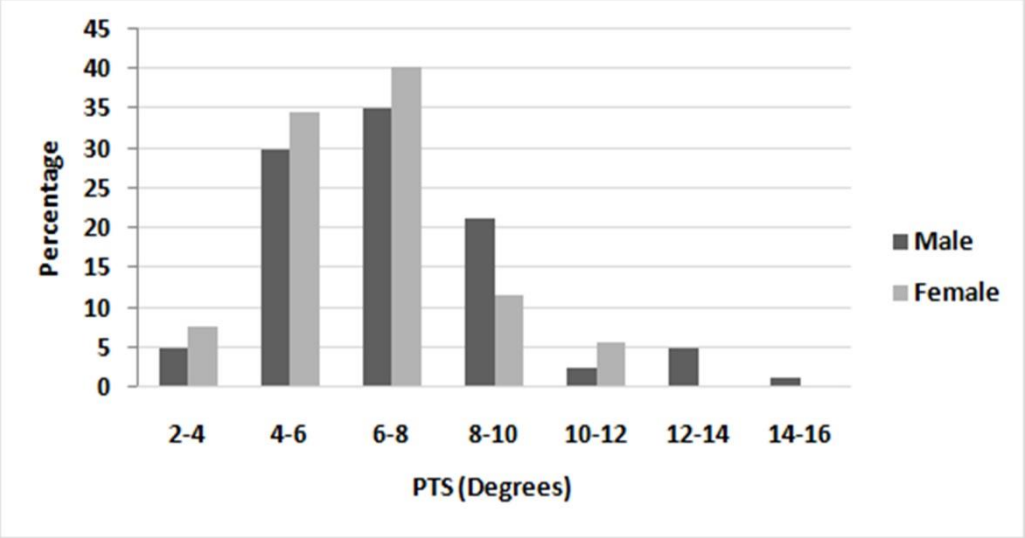

Fig 4- Percentage of different tibial plateau slope for both sexes in lateral compartment

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

Table 1- Number of study males and females in terms of tibial plateau slope less or more than 10 degrees in medial and lateral compartments

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

Discussion

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

Concern for impact of PTS on knee joint loading has led to 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±2.48 degrees in the medial compartment and 6.85±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. (16) reported the slope value of 14±3.7° (range: 7- 22°) in 50 Americans. Matsuda et al. (17) obtained this value about 10.7 ° (range: 5- 15.5°) in 30 Japanese patients, and Chiu et al. (18) found the mean slope of 14.7±3.7° (range: 5- 22°) in 25 Chinese cases.

In a study by Hosseinzadeh et al. (19) conducted in Iran, the slope value was 9.4±1.8° (range: 2- 18°) in 108 knees. In another study by Qureyshi et al. (20), the slope value was reported 9.3±1.4° (range: 1- 19°) in 431 knees.

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 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 ($P \geq 0.05$), this confirms 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 elevation in medial plateau. This increase is 5.3 degrees per each square millimeter increase in plateau in the medial compartment, and 3.9 degrees in the lateral compartment.

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

In an in vitro study, Garg and Walke (25) observed significant improvement in motion in PTS with 10 degrees. 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 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. (29) showed that changes in PTS might cause patella baja.

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).

Conclusion

The results revealed the difference of posterior tibial Slope in Iranian population compared to other communities, thus conducting more detailed studies on the cause of the mentioned difference and computation of real slope values of the Iranian populationis the inevitable.

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

Due to the significance of PTS, retaining normal knee slope is important during arthroplasty and High tibial osteotomy(14, 30 and 31).

Results and data obtained from this study can be used in PTS reconstruction in knee surgery.

Suggestions

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 the two variables of height and weight in the patients as independent factors; future studies should cover these issues.

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Acknowledgment

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Disclosure

Authors report no conflict of interest.

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