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Original Research Article

Radiological evaluation and correlation of Posterior tibial slope and Metaphysio-Diaphyseal angle in osteoarthritic patients planned for Total knee arthroplasty

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Abstract:

Background: Posterior tibial slope (PTS) plays a very important role in kinematics and biomechanics of the knee joint. The posterior inclination of the tibial plateau relative to the longitudinal axis of tibia is defined as posterior tibial slope. Metaphysio-diaphyseal angle (MDA) is the angle between longitudinal axis of tibia and proximal tibia metaphysis. MDA is a recent radiological concept gaining clinical significance and its role in Total Knee Arthroplasty (TKA) is under study and research. The study was performed to evaluate and correlate the PTS and MDA using lateral knee radiograph in osteoarthritic patients planned for TKA.

Materials and Methods: This prospective study was conducted in the Department of Orthopaedics, Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, India from August 2020 - July 2021. Permission was obtained from the Institutional Ethical Committee and departmental scientific committee. A total of 36 cases of knee osteoarthritis were enrolled in this study. Posterior cruciate ligament substituting TKA was done with the same jig to achieve different PTS in different patients. MDA, pre-operative PTS, and post-operative PTS were calculated. All the observations and measurements of PTS and MDA were analyzed using appropriate statistical analysis.

Result: The mean MDA of the study sample was 20.11 degree with standard deviation of 3.23 degree. The mean Pre-operative PTS of the study sample was 13.68 degree with standard deviation of 4.06 degree. The mean Post-operative PTS was 9.27 degree with standard deviation of 4.42 degree.

Conclusion: In this study we found that females undergoing total knee replacement have nearly the same PTS as males. Also, age had no significant correlation with variation in PTS of the patients. Patients with MDA above 20° tend to have post-operative PTS significantly higher than the desired values making them vulnerable to complications. Thus, MDA should be considered during planning of a total knee arthroplasty. Necessary modifications (such as pre-operative templating, intraoperative jig angle setting and using intramedullary jigs) should be done in the current protocols to achieve desired PTS in patients having higher MDA.

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Keywords: Posterior tibial slope, Metaphysio-Diaphyseal angle, Osteoarthritis & Total Knee Arthroplasty.

1. INTRODUCTION

The posterior tibial slope plays a vital role in the kinematics and biomechanics of the knee joint. The tibial shear force and anterior tibial translation significantly rises when PTS is high.[1] PTS plays an important role which influences the sagittal alignment of knee joint.[2]
Various methods for assessing PTS of the tibia ranges from direct cadaveric measurements, radiographs to CT scans and MRI.[3]
The normal PTS has been quoted as 5-10°, with racial variations.[4] PTS is an important factor affecting postoperative range of motion (ROM) following TKA. Altered PTS in osteoarthritis leads to reduced ROM. Studies done in the Chinese, Japanese, and Pakistani populations (Asians) have documented a difference in the PTS in their respective population from the Caucasians, which is responsible for differences in the range of flexion in these populations.[5,6]
There is a significant correlation between the PTS and the MDA directly.[7] Thus for achieving the desired PTS, MDA shall be considered during planning of a total knee replacement.
Aim and objectives of the present study are as follows:
1. To find the mean PTS and MDA in osteoarthritic patients planned for TKA.
2. To find a correlation between MDA and post-operative PTS achieved.

2. MATERIAL & METHODS

This prospective study was conducted in Department of Orthopaedics, Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, India from August 2020 - July 2021. Permission was obtained from the Instituitional Ethics Committee and departmental scientific committee. A total of 36 cases were enrolled in this study.
The patients for planned TKA were admitted a few days before surgery. Patients who gave informed written consent were enrolled for the study.
Posterior tibial slope (Figure 1) is measured by 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.[8] Metaphysio-diaphyseal angle (Figure 2) is formed between two lines: first line is the proximal anatomical axis of the tibia and the second is the axis of the proximal tibia metaphysis.
Pre-operative assessment as per the pre-decided detailed proforma was done which included history taking, examination, investigations and x-rays lateral and antero-posterior views.
Post-operative PTS was calculated from lateral radiograph done on postoperative day 2.
Final correlation between pre-operative PTS, MDA, and post-operative PTS was calculated using appropriate statistical calculations.

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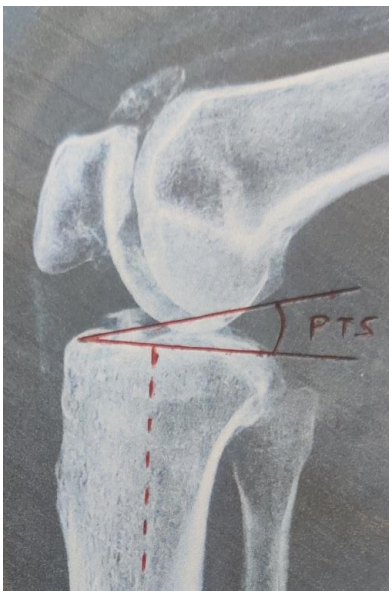

Figure 1: Calculation of pre-operative posterior tibial slope

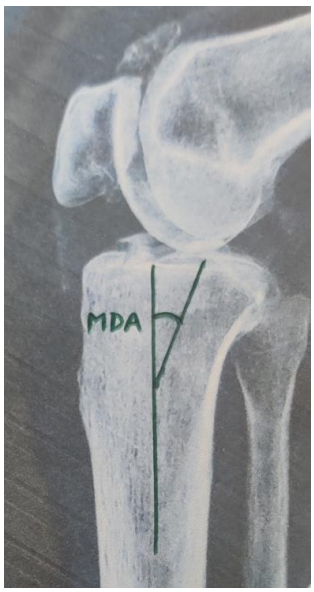

Figure 2: Calculation of metaphysio-diaphyseal angle

Inclusion criteria:

1. Patients willing for treatment and given informed written consent
2. Use of extra-medullary jig to cut tibia intra-operatively

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Exclusion criteria:

1. Patients not willing to be a part of the study
2. Patients medically unfit for surgery
3. Patients having chronic neuromuscular problems affecting the limb
4. Patients with complex primary TKA; Range Of Motion <50°, Angular deformity >10°, Fixed Flexion Deformity >30°
5. Patients previously operated around knee joint
6. Patients with extra-articular deformity
7. Revision TKA

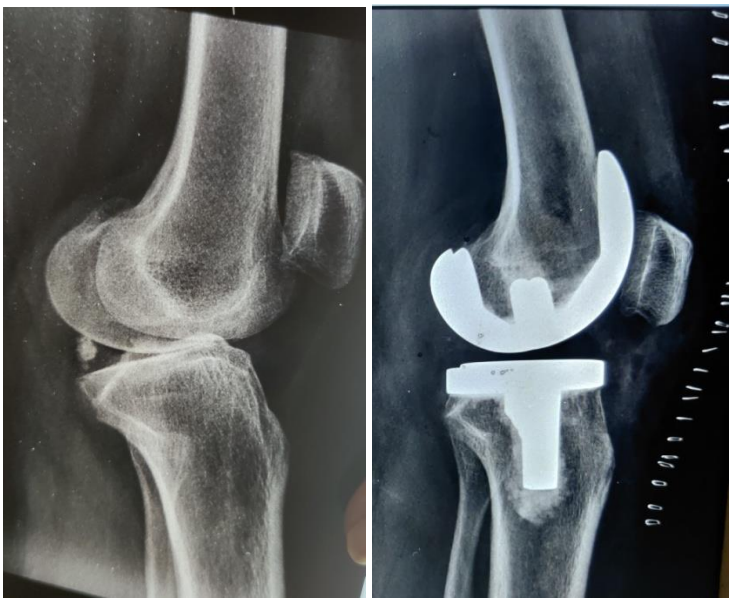

Figure 3: Pre-operative and post-operative X-rays of Case 1 for calculation of angles

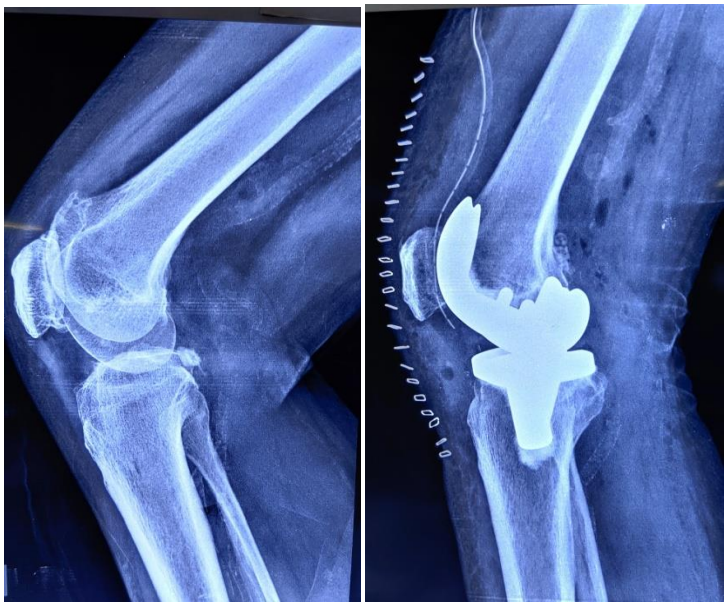

Figure 4: Pre-operative and post-operative X-rays of Case 2 for calculation of angles

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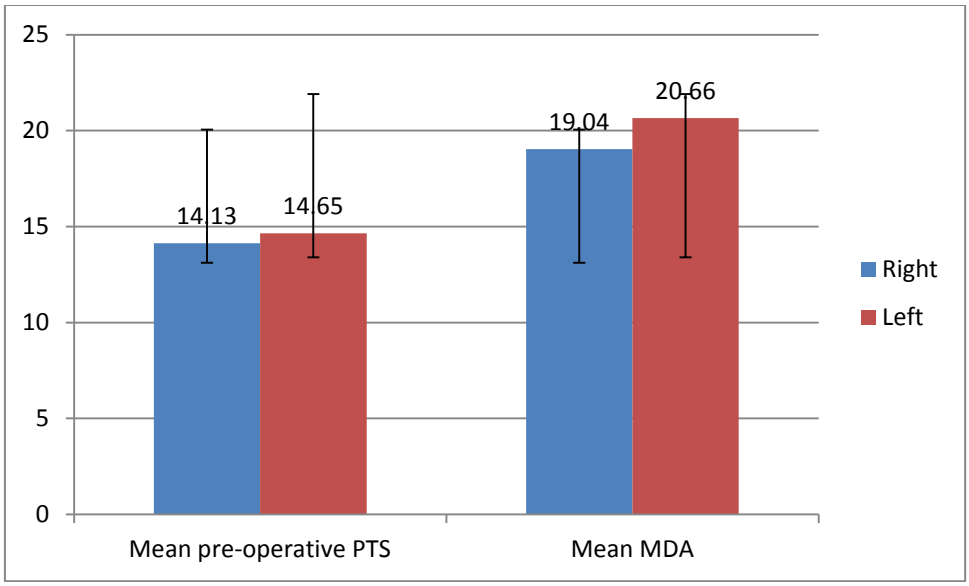
3. RESULTS

Age distribution -
The study includes patients of osteoarthritis between 46-70 years with majority in age group 50–60 years and a mean age of 56.34 years.
Laterality –

Table No. 1: Side variation in pre-operative PTS and MDA

Side of knee	Number of cases	Mean pre-operative PTS	Mean MDA
Right	16	14.13	19.04
Left	20	14.65	20.66



56% knees were left sided (n=20), while the remaining 44% knees were right sided (n=16). The mean PTS for right-sided knee (n=16) was 14.13° (10 °-19°), and the mean MDA was 19.04° (10°-29°). The mean PTS for left-sided knee (n = 20) was 14.65° (7°-20°), and the mean MDA was 20.66° (14°-25°).
Gender variation –

Table No. 2: Gender variation in pre-operative PTS and MDA

Gender	Number	Mean pre-operative PTS	Mean MDA
Male	15	14.73	19.64
Female	21	14.81	20.13

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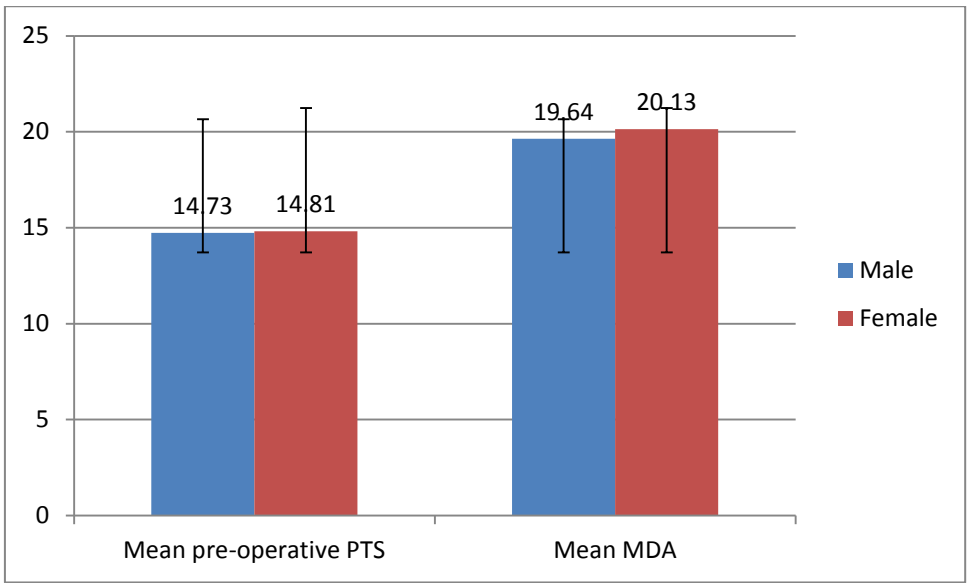

58% knees belonged to female patients whereas remaining 42% knees were of male patients. The mean pre-operative PTS for male patients (n=15) was 14.73° (7°-19°) and the mean MDA was 19.64° (10°-26°). The mean pre-operative PTS for female patients (n=21) was 14.81° (8°-20°) and the mean MDA was 20.13° (12°-29°).

Pre-operative PTS, MDA & post-operative PTS of study sample –

Table No. 3: Pre-operative PTS, MDA & post-operative PTS of study sample

	Range	Mean	Standard Deviation
Pre-operative PTS	7 - 20	13.68	4.06
MDA	10 - 29	20.11	3.23
Post-operative PTS	4-15	9.27	4.42

The mean pre-operative PTS of the study sample was 13.68° with standard deviation of 4.06°. The mean MDA of the study sample was 20.11° with standard deviation of 3.23°. The mean post-operative PTS was 9.27° with standard deviation of 4.42°.

Dividing Sample into Two Groups -

The median of MDA was 20°. Hence, to evaluate the role of MDA on post-operative PTS, the sample was divided into two groups.

Group A with MDA less than or equal to 20°.

Group B with MDA more than 20°.

Table 4: Mean of pre-operative PTS, MDA & post-operative PTS of Group A & B

	Group A	Group B
Number of cases	24	26
Mean pre-operative PTS	11.83	17.19
Mean MDA	17.36	24.09

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Mean post-operative PTS	7.49	13.03

The mean pre-operative PTS of Group A was 11.83° (7°-14°), whereas mean pre-operative PTS of Group B was 17.19° (13°-20°). Mean MDA of Group A was 17.36° whereas mean MDA of Group B was 24.09°. The mean post-operative PTS of Group A was found to be 7.49° (4°-12°), whereas mean post-operative PTS of Group B was 13.03° (9°-15°).

4. DISCUSSION

Various methods for assessing PTS are available, however due to financial constraints we have used radiographic calculation. The age- and gender-specific PTS have not been fully mapped out for all populations. Among the few studied, it has been found to be different among different races.[2,6,7,8,9,10,11] Asian population has been found to have an increased PTS as compared with Caucasian population. At the same time, some other authors have reported lower PTS in the Asian population.[10,12] The variations in PTS in Asian population as compared above maybe due to difference in reference axis and the methodology used in calculation.[4,7,8,9,13]
Moreover, it has been found that the PTS increases with the onset of osteoarthritis.[10,14,15]
As was noted in Yoga et al.[9] and a systematic review by Merchant et al.[16], the slope was nearly equal in males and females in this study. Dargel et al.[17] studied 60 human cadaver knees and concluded that male linear knee joint dimensions were significantly larger when compared with females but the difference was not significant, and hence, there was no need for gender-specific implant design or technique to be employed in TKA. However, Khattak et al.[4] and Didia et al.[13] did find a significant difference in the PTS between the two genders.

We found in the present study that in osteoarthritic knees pre-operative PTS slope varied from 7°- 20° averaging 13.68° which is similar to the values reported in literature by Mohanty et al.[2] (11.64°) and Chiu et al.[5] in the Chinese population (13.1°). While other studies, such as Yoga et al.[9] (10.1°), Khattak et al.[4] (13.65°), Yoo et al.[6] (10.6°) and Didia et al.[13] (12.3°) have measured PTS for normal knees only and not for osteoarthritic knees.

In the present study we found that patients with higher preoperative PTS end up with higher postoperative PTS which is similar to the study by Yoga et al.[9], they also suggested that higher postoperative PTS may increase the range of flexion, but these patients may not achieve full extension, which is not desirable. In this condition, to achieve full range of extension, an excess resection of proximal tibia needs to be taken. As per Bartel et al.[10], when excess bone is resected in the proximal tibia, the stiffest and strongest cortical bone is removed, and the remaining weaker and less stiff cancellous bone stock often is inadequate to support the physiological loads of knee.

The present study measured MDA in osteoarthritic knees with average value of 20.11°. While MDA measured by Mohanthy et al.[2] in arthritic knees was 23.76°, rest of the studies didn't measure MDA in arthritic knees. Mohanty et al. studied 100 cases and concluded a positive correlation between MDA and PTS; with MDA being an independent factor affecting the accuracy of extramedullary jigs in TKA. Mohanthy et al. emphasized the role of MDA to achieve the desirable postoperative PTS and also to aim at a PTS of 3° to 5° for safety and minimizing errors. They have suggested a reference point of 20° for MDA; above and below this 20° value of MDA, the postoperative PTS gets altered. When MDA is less than 20° and postoperative PTS of less than 3° is aimed, then it might end up in a reverse tibial slope (anterior), whereas when it is greater than 20° and a PTS of more than 5° is aimed at, then

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this might result in a PTS much more than 5°. The anterior tibial slope might cause wear problems and the higher PTS of more than 5° may result in loss of extension and component loosening. Bai et al.[15] noted that anteriorly sloped tibial components led to a tendency to posterior micromotion and thus more wear of implant in TKA.

The present study aimed for a post-operative PTS within 3°–7° in all cases. If MDA had no effect on the desired PTS, the post-operative PTS of Group A and Group B should have been nearly same, and statistically, no significant difference should have been noted. However, the post-operative PTS of Group A (MDA <20°) and Group B (MDA >20°) was 7.49° and 13.03° respectively. This strongly suggests that, in patients with high MDA (Group B), the achieved PTS was higher than desired PTS.

5. CONCLUSION

In the present study, females undergoing total knee arthroplasty have nearly the same slope as males. Also, age had no significant correlation with variation in Posterior tibial slope of the patients. A significant correlation between the pre-operative PTS and the MDA was observed in the study. As PTS and MDA vary in the same direction, there is a substantial risk of error when cutting the tibia based on an extramedullary jig. This error with respect to desired 0–7° of post-operative slope in every patient gets substantial in patients with a higher MDA (Group B in the study). Patients with MDA above 20° tend to have post-operative PTS significantly higher than the desired values making them vulnerable to complications. In a patient with a MDA <20°, planned PTS <3° should be avoided as it may lead to anterior tibial slope which is associated with adverse biomechanics and in cases with MDA >20°, a planned PTS >7° should be avoided.

Thus, MDA should be considered during the planning of a total knee replacement. Necessary modifications (such as pre-operative templating, intraoperative jig angle setting and using intramedullary jigs) should be done in the current protocols to achieve desired PTS in patients having higher MDA.

The present study had certain limitations like small sample size, and medial and lateral tibial slope variation in same patients.[2,4,8,13] For simplification, the two plateaus were assumed to be equal. Single observer calculated the angles by manual technique using lateral radiographs and goniometer. Computer-assisted (navigation-assisted TKA) TKA was not available in the institution where the study was conducted. Computed tomography is the most accurate method in measuring PTS,[2,13,18,19] however due to financial constraint CT was not used in this study. The sample was collected from the patients of osteoarthritic knees; hence the results of PTS do not apply to the general population.

In our future course of study, we seek to continue this study with more samples to validate PTS and MDA as arthritic markers and its statistical significance in terms of sensitivity and specificity. There seems a need for more research on Indian population to develop better implant and techniques for total knee arthroplasty in the Indian subcontinent.

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