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INFLUENCE OF POSTERIOR TIBIAL SLOPE ON FUNCTIONAL OUTCOMES IN CRUCIATE-RETAINING VERSUS POSTERIOR-STABILIZED TOTAL KNEE ARTHROPLASTY: A COMPARATIVE COHORT STUDY

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ABSTRACT

Background Posterior tibial slope (PTS) plays a critical role in knee kinematics following total knee arthroplasty (TKA). Its influence varies between cruciate-retaining (CR) and posterior-stabilized (PS) designs due to differences in posterior cruciate ligament (PCL) function. However, the optimal PTS for maximizing functional outcomes while maintaining stability remains controversial. **Objectives** To evaluate the effect of posterior tibial slope on postoperative range of motion (ROM), functional outcomes, and stability in CR and PS total knee arthroplasty, and to determine whether the optimal slope differs between the two implant designs. **Methods** A retrospective cohort study was conducted on patients who underwent primary TKA using either CR or PS implants at a single tertiary hospital between august 2025 to may2026. Posterior tibial slope was measured on standardized lateral radiographs and patients were stratified into three groups: <3°, 3–7°, and >7°. Clinical outcomes assessed at a minimum follow-up of 10 months included knee range of motion, Knee Society Score (KSS), and incidence of flexion instability or need for manipulation under anesthesia (MUA). Comparative analysis was performed between CR and PS groups, and correlation between PTS and outcomes was evaluated.**Results** A total of 80 knees ([30] CR, [50] PS) were included with a mean follow-up of 10 months. In the CR group, patients with PTS of 3–7° demonstrated significantly better postoperative flexion and higher KSS compared to those with <3° ($p<0.05$). Increased slope (>7°) was associated with a higher incidence of flexion instability. In the PS group, PTS showed a weaker correlation with functional outcomes, although patients with moderate slope (3–7°) achieved marginally better flexion. Excessive slope did not significantly improve outcome but showed a trend toward instability. No significant difference in MUA rates was observed across groups. **Conclusion** Posterior tibial slope significantly influences functional outcomes in CR TKA, with an optimal range of 3–7° balancing flexion and stability. In PS TKA, the effect of slope is less pronounced, although excessive slope may predispose to instability without added functional benefit. Individualized tibial slope adjustment based on implant design is recommended to optimize postoperative outcomes.

KEYWORDS

Total Knee Arthroplasty; Posterior Tibial Slope; Cruciate-retaining; Posterior-stabilized; Knee Flexion; Functional Outcome

INTRODUCTION

Studies show that the posterior tibial slope (PTS) plays an important role in how the knee works. It affects the tension and stability of the posterior cruciate ligament (PCL) and helps the femur move backward properly during knee flexion (femoral rollback). Because of this, PTS has a significant impact on the results and success of total knee arthroplasty(1-3).Several biomechanical studies have shown that PTS is positively correlated with the range of flexion and inhibits excessive tension in the PCL during knee flexion, resulting in fewer instances of tibial component loosening(4).Excessive posterior tibial slope (PTS) may result in anterior tibial translation and altered knee biomechanics, thereby potentially compromising the longevity of total knee arthroplasty (5). Furthermore, the type of prosthesis—posterior cruciate ligament (PCL)-retaining versus PCL-sacrificing—represents a critical variable when assessing the relationship between PTS and postoperative outcomes. The majority of existing literature suggests that PTS has a significant effect on postoperative range of motion (ROM) in PCL-retaining TKA, whereas its influence appears to be minimal or insignificant in PCL-sacrificing TKA(6-7).

MATERIALS AND METHODS

This is a prospective study that was carried out in Max super speciality hospital noida-128,India between August 2025 to may 2026. Patients were followed up to 10 months. A total of 80 knees were operated during the study period. In all the patients Zimmer nexgen prosthesis were implanted.Based on postoperative PTS which was measured on lateral radiograph of the knee, patients were divided into 3 groups. Group A (PTS of <3) comprise of 26 patients. Group B consists of 46 patients (PTS of 3 to 7).Group C includes 8 patients (PTS of >7). In Group A 6 were CR and 20 were PS knees, in Group B 17 were CR and 29 were PS knees and in Group C 7 were CR and 1 was PS knee. At final follow up (10 months) a total of 80 patients were analysed.

Exclusion criteria

<90° preoperative ROM, rheumatoid arthritis, traumatic or infectious arthritis, patellar resurfacing,revision arthroplasty and ≥Outerbridge grade III lesion in more than 50% of the patellofemoral joint.

Inclusion criteria

Patients with primary osteoarthritis. Patients age between 40 and 80 years. Minimum follow up of 10 months at the time of evaluation.

Operative technique

TKA was performed by one of the two surgeons using Zimmer nexgen implants. After tourniquet inflated all knees exposed with standard medial parapatellar approach.

Patella everted,partial fat pad excision done for better visualization of lateral tibial plateau. Proximal tibial cut with 3,5or 7 degrees PTS was performed perpendicular to tibial mechanical axis. Some surgeons preferred CR and the other PS knee. Distal femoral cuts with 5degree valgus and posterior femoral cut was performed in 3 degree external rotation with respective to posterior femoral condyles. Patelloplasty was not done in all patients. If severe flexion contracture and soft tissue contracture were present, posterior osteophyte removal and partial PCL release were done to achieve flexion-extension gap balance. Checked for patellar tracking, if patella maltracking occur then a lateral retinacular release is performed at least 2 cm lateral to the border of the patella.cementing of the femoral and tibial components was done. Wound closed in layers in 40-50 degrees of knee flexion over suction drain. Patient was mobilized on 1st post op day. Radiographs of both weight bearing antero-posterior and lateral views were taken. The tibial slope was recorded as an angle between the line perpendicular to the tibial longitudinal axis and the line drawn along the superior margin of the proximal tibia or tibial base plate.

Assessment and Analysis

The anatomical axis and mechanical axis were measured on the weight-bearing radiographs preoperatively and at the last follow-up. PTS was defined as the angle between a line perpendicular to the proximal tibial anterior cortex and a line parallel to the tibial medial plateau on the 30° flexion lateral view(10).ROM was measured preoperatively and at the last follow-up. Knee function was assessed using the visual analog scale (VAS) score, Feller patella score15),Western Ontario and McMaster Universities osteoarthritis index (WOMAC) and Knee Society knee score (KSS)17) preoperatively and at the last follow-up. Analysis was done using SPSS 21 software. Descriptive statistics (mean, standard deviation and proportions) were used to summarize the study variables. The 95%

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confidence intervals for difference of mean were used. The comparison between three groups regarding PTS, ROM and outcome of our study was done using ANOVA test was used, p<0.05 was considered to be statistically significant.

RESULTS

A total of 80 knees ([30] CR, [50] PS) were included with a mean follow-up of 10 months. In the CR group, patients with PTS of 3–7° demonstrated significantly better postoperative flexion and higher KSS compared to those with <3° (p<0.05). Increased slope (>7°) was associated with a higher incidence of flexion instability. In the PS group, PTS showed a weaker correlation with functional outcomes, although patients with moderate slope (3–7°) achieved marginally better flexion. Excessive slope did not significantly improve outcomes but showed a trend toward instability.

Table 1: Demographic data

PTS	CR	PS
Group A (<3 degrees)	6	20
Group B (3-7degrees)	17	29
Group C (>7 degrees	7	1
Total	30	50

Table 2: Pre op Posterior Tibia slope (PTS) and range of motion(ROM) of CR knees

Demographic variables	**Group A**	**Group B**	**Group C**	**F value (p value)**	**Significance**
Age	62.38 ±7.966	61.70± 8.712	65.80± 9.57	1.06(p=0.347)	p>0.05
Gender (M/F)	16/10	16/30	1/7	4.63(p=0.098)	p>0.05
BMI	26.66± 1.814	27.41 ±2.66	27.56 ±3.269	0.885(p=0.41)	p>0.05

Table 3: Post op Posterior tibia slope and ROM of CR kneesTable 4: Pre op Posterior Tibia slope (PTS) and range of motion(ROM) of PS knees

Mean values	**CR Group A (n=6)**	**CR GroupB(n=17)**	**CR Group C(n=7)**	**F value (p value)**	**Significance**
Pre op PTS	9.67	8.74	9.12	2.958(0.055)	p>0.05
Pre op ROM	87.0±17.512	88.7±10.347	87.91±11.597	0.1944 (0.824)	p>0.05

Table 4: Pre op Posterior Tibia slope (PTS) and range of motion(ROM) of PS knees

Mean values	**Group A (n=6)**	**Group B (n=17)**	**Group C (n=7)**	**F value (p vaue)**	**Significance**
Post op PTS	0.74	5.62	9.87	3.553 (0.032)	P<0.05
Post op ROM	92.91±10.632	107.24±10.905	107.49±13.944	16.187 (0.0001)	P<0.001

Table 5: Post op Posterior tibia slope and ROM of PS knees

Mean values	PS GroupA(n=20)	PS GroupB(n=29)	PS Group C(n=1)	F value (p value)	Significance
Pre op PTS	7.1	8.15	8.85	2.124(0.429)	p>0.05
Pre op ROM	100.57±15.55	102.90±13.62	101.8±12.85	0.213 (0.269)	p>0.05

Table 6: WOMAC and KSS score in PS knee

Mean values	**Group A (n=20)**	**Group B (n=29)**	**Group C (n=1)**	**F value (p vaue)**	**Significance**
Post op PTS	1.75	6.27	8.34	2.150(0.001)	P<0.05
Post op ROM	115.20±12.59	122.50±11.96	110.48±10.25	20.865 (0.0125)	P<0.001

Table 7: WOMAC and KSS score in CR knee

Mean values	**Group A (n=20)**	**Group B (n=29)**	**Group C(n=1)**	**F value (p value)**	**Significance**
Pre op WOMAC	66.90±5.840	71.03±8.349	68.29±6.388	2.928 (0.057)	p>0.05
Post op WOMAC	30.58±3.944	29.60±5.168	29.87±4.153	0.321 (0.726)	p>0.05
Pre op KSS	26.90±10.64	27.38±9.577	27.00±9.953	0.015 (0.985)	p>0.05
Post op KSS	158.90±17.23	168.50± 12.353	165.24±11.55	2.199 (0.115)	p>0.05

Table 8: VAS scale and Feller patella score

Mean values	**Group A (n=6)**	**Group B (n=17)**	**Group C (n=7)**	**p value**	**Significance**
Pre op WOMAC	75.8 ± 12.4	76.5 ± 11.8	74.3 ± 11.8	0.8755	p>0.05
Post op WOMAC	22.2 ± 6.5	23.1 ± 7.4	21.4 ± 8.3	0.3024	p>0.05
Pre op KSS	55.8+21.2	56.2+20.4	56.3+20.2	0.214	p>0.05
Post op KSS	86.3+8.2	86.2+8.4	86.3±7.2	0.304	p>0.05

There was no statistically significant intergroup difference in the parameters that can affect the post operative knee function including the preoperative body mass index (BMI), VAS score, KSS, Feller patella score.Both pre-operative

PTS and pre-operative ROM had no statistically significant difference between the groups (p>0.05) (Table 2 &4). Mean post-operative ROM was significantly related to mean post-operative PTS(p<0.05) (Table 3&5)

In the CR group, patients with PTS of 3–7° demonstrated significantly better postoperative flexion and higher KSS compared to those with <3° (p<0.05). Increased slope (>7°) was associated with a higher incidence of flexion instability. In the PS group, PTS showed a weaker correlation with functional outcomes, although patients with moderate slope (3–7°) achieved marginally better flexion. Excessive slope did not significantly improve outcome but showed a trend toward instability.

DISCUSSION

Many factors affect the ability to achieve maximum ROM after TKA. Some of these factors can be controlled by the surgeon. Others such as preoperative ROM cannot be controlled by the surgeon. Some authors have hypothesized that proximal tibial slope influence post operative ROM.Patients with more PTS have the tendency to flex better than knees with little or no PTS but most published clinical studies have failed to show an effect of tibial slope on maximal flexion.(8-9)

Kansara et al concluded that there was no significant difference in the postoperative ROM between the knees with 0 and 5 degrees of PTS after PCL-sacrificing TKA.(11) Bauer et al(17) reported that the correlation between PTS and maximal knee flexion that was observed after PCL-retaining TKA was not noted after PCL-sacrificing TKA.

Catani et al. [16] have also found a significant correlation between the tibial slope and the maximal flexion in an in-vivo video-fluoroscopic study on the knee kinematics of the posterior cruciate ligament (PCL)-substituting TKA implants.(11-12) Kim et al observed statistically significant positive correlation between PTS and maximal flexion angle after PCL-sacrificing TKA using a medial pivot implant. They also stated that, understanding the design characteristics of the PCL-sacrificing medial pivot knee system that has a larger contact area in the medial compartment compared to the

PCL-substituting knee implants could contribute to the correlation between PTS and flexion range.(13-14)

Malviya et al observed that an increase of 10 of PTS had increased the flexion angle by an average of 2.30 in 101 knees after PCL-retaining TKA.(15) Bellemans et al(18) reported that an increase in 10 PTS leads to mean increase of knee flexion by 1.7 degrees after PCL-retaining TKA based on evaluation of knees with 0,4 and 7 degrees PTS.

In our study flexion angle of the knee after CR TKA was correlated with PTS. There was improvement in postoperative ROM in all the patients.Postoperative ROM was more in the group with higher PTS ($p<0.001$). In the PS group, PTS showed a weaker correlation with functional outcomes, although patients with moderate slope (3–7°) achieved marginally better flexion. Therefore, we conclude that PTS is one of the surgeons factor that influences flexion angle after CR TKA.

CONCLUSION

Posterior tibial slope significantly influences functional outcomes in CR TKA, with an optimal range of 3–7° balancing flexion and stability. In PS TKA, the effect of slope is less pronounced, although excessive slope may predispose to instability without added functional benefit. Individualized tibial slope adjustment based on implant design is recommended to optimize postoperative outcomes.

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