Original Research

Assessment Of Posterior Tibial Slope In Total Knee Arthroplasty And Its Effect On Functional Outcome

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Abstract:
Context: A range of motion (ROM) after complete knee arthroplasty has been hypothesized to benefit from posterior slope.
Aims: Accuracy evaluation of a <3°, 3-6°, and a >6° degrees posterior sloped cutting guide and the effect of the posterior tibial slope on postoperative ROM.
Settings and Design: A prospective interventional study conducted at Department of Orthopaedics, Dr. Babasaheb Ambedkar Central Railway Hospital, Byculla.
Methods and Material: Seventy-five consecutive patients underwent TKA using a cutting block and intramedullary cutting guide designed to impart a <3° degrees posterior tibial slope (Group I, n=40). A 3-6° degrees tibia cutting block was used in 24 subsequent patients (Group II, n=24) and a >6° tibia cutting block was used in 11 patients (Group III, n=11).
Statistical analysis: Frequency, percentage and ANOVA were used for qualitative data and mean, and standard deviation were used for quantitative data.
Results: VAS score at different intervals from preoperative to post-operative periods showed significant findings up to 6 months follow-up, however, group III showed insignificant findings at 6 months to the one-year interval. Similarly, WOMAC score at different intervals showed statistically significant in the initial 6 months in all three groups except in group III from 6 months to 1 year interval which is insignificant. There was statistical significance in all three groups for the forgotten score (FJS) and knee society score (KSS) at all time intervals.
Conclusions: For an effective functional result, we recommend a PTS of less than 3° and between 3-6° can be recommended for TKA.
Key-words: Posterior tibial slope, Total knee arthroplasty, Postoperative range of motion, VAS, WOMAC
Key Messages: The posterior tibial slope can have significant implications for knee biomechanics, stability, and overall function after TKA. It's important to note that the optimal posterior tibial slope angle is still a matter of debate. A PTS of less than 3° and greater than 3-6° can be recommended for the TKA based on our study results.

Introduction:

A desirable result of total knee arthroplasty is maximizing postoperative range of motion (ROM). Increased motion has been linked to better function and higher patient satisfaction. The eventual postoperative ROM could be impacted by several factors. These factors include the condition of the soft tissues (such as flexion contracture or valgus or severe tibiofemoral varus), preoperative range of motion, the choice of surgical approach, surgical technique, prosthetic geometry as well as size, preservation / substitution of the posterior cruciate ligament, and the prosthetic positioning, height of the joint line, and also the anterior-posterior tibial cut angle (tibial slope).[1,2] The precise position of the prosthetic components is essential for the outcome of a total knee arthroplasty (TKA). The surgeon can usually adjust the angle of the proximal tibial incision in the sagittal plane when using the instruments systems used to conduct a total knee arthroplasty. These instruments include fixed-angle cutting blocks which are available in a variety of angles as well as cutting jigs that can be changed to the necessary posterior inclination. According to computer simulations, raising the posterior tibial tilt may increase postoperative range of motion.[3]Some authors observed that among the many variables influencing postoperative range of motion, such as sex, age, body mass index (BMI), preoperative ROM, prosthesis design, and surgical procedures, the posterior tibial slope (PTS) after TKA linked with postoperative ROM.[4,5] The kinematics of the knee joint are impacted by the PTS, which is the posterior inclination in geometry of the tibial plateau.[6,7] Studies have suggested that the posterior tibial slope, which promotes femoral rollback, has an association to the stability and tension of the posterior cruciate ligament (PCL) and the biomechanics of the knee joint. The clinical results of total knee arthroplasty (TKA) are thus profoundly affected by it.[8]The style / type of cutting jig, saw blade deflection, jig stability, deviation in the surgeon's hands, and other factors could theoretically cause variations in the proximal tibial slope. Changes in inclination have been demonstrated to affect kinematics and force distribution in previous cadaveric and biomechanical experiments. The changes in knee kinematics brought on by the angle change have been shown by biomechanical studies. Standard cutting guides do not appear to be able to accurately change tibial slope, and it is still unclear how PTS alterations would affect the results of patient satisfaction. The purpose of this study was to examine into how PTS changes affected clinical outcomes and functional outcomes in TKA.

Subjects and Methods:A total of 75 patients having Grade 4 osteoarthritis of the knee undergone cruciate-retaining and fixed-bearing TKAs performed at Dr. Babasaheb Ambedkar Central Railway Hospital, Byculla between June 2019 to june 2022. Patients with age between 55 to 75 years, who underwent cruciate retaining TKA for primary Osteoarthritis Grade 4 and were independently ambulatory before surgery were included in the study. Exclusion criteria for the study included patients with a history of high tibial osteotomies and distal femoral osteotomies, revision of total knee replacement (TKR) patients, previous knee surgery, active infection, rheumatoid arthritis, as well as secondary arthritis brought on by inflammatory diseases. On the basis of the net posterior tibial slope, the patients were divided into three groups: Group I < 3.0^0 had a posterior tibial slope (PTS) (n=40), Group II > 3.0^o- 6.0^o ((n=24) PTS and Group III > 6^o PTS (n=11).

Operative Technique : The aim of the operation was to achieve a painless stable knee with neutral alignment and a laxity of less than 5 mm with respect to the collateral ligament. The same surgeon utilized a medial parapatellar technique to perform all of the operations. A preoperative antibiotic was given to all the patients. All the surgeries were done using a tourniquet. At first infrapatellar fat pad was removed followed by the removal of osteophytes and excision of the anterior cruciate ligament and sparing of the posterior cruciate ligament and removal of the meniscus. Tibial cut was taken perpendicular to the tibia's long axis. The posterior tibial slope of the tibial cut was matched to the native posterior slope (generally reduce slope from the preop slope) of the patient. Using an intramedullary guide, a distal cut on the femur was made. The orientation of the femoral component's was ascertained through the utilization of Whiteside's line, the Trans-epicondylar line (TEA), the Posterior femoral condylar axis, and the alignment of proximal tibial cuts. The rotational alignment of the tibial tray was established by referencing the medial one-third of the tibial tubercle. By employing the Measured Resection Technique, the ligaments were balanced, and their stability was examined with equal flexion as well as extension gaps. When the patella's native articular cartilage began to erode due to arthritis, patellar resurfacing was necessary. After determining the proper prosthetic size, the collateral ligaments were balanced as required based on ligament tension assessed during functional testing of the prosthetic implant. No surgery involved the use of the drain. Postoperatively, patients were given immediate access to full weight bearing on the operated knee and range of motion in the knee. Active quadriceps strengthening exercise (QSE), vastus medialis obliquus (VMO) exercises were suggested. Oral Rivoraxaban 10mg was administered for deep venous thrombosis prophylaxis for 14 days.

Assessment and Analysis : Patients were assessed for their functionality using the visual analogue score (VAS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, the functional knee society score, the forgotten knee joint score, the kujala score, the feller patellar score, the objective knee society score, and the Oxford knee score both preoperatively and postoperatively, at the three-month, six-month, and one-year follow-up points. Based on the Net posterior tibial slope, data has been collected and compared. The net posterior tibial slope is calculated by subtracting the post-operative posterior tibial slope from the preoperative posterior tibial slope (PTS = P1-P2), where p1 represents the preoperative posterior tibial slope and p2 represents the post-operative posterior tibial slope.Statistical analysisThe SPSS version 25 was used to analyse the data. Frequency and percentage were used to describe qualitative data and mean and standard deviation were used for expressing quantitative data. The ANOVA test was used for comparing the parameters that varied across the groups to determine whether the differences were statistically significant or not. P value < 0.05 was considered as statistically significant.

Results:

Study results showed a total of 75 patients between the age of 55-75 years with a mean age of 61 years and a median of 63 years with 39 females and 36 males with an overall mean BMI of the patient 26.2 and average durations of hospital stay over 10 days. Based on the patients' BMI, there was no statistically significant difference in the VAS scores in any of the three groups. Improvement in VAS, WOMAC, and forgotten joint score from preoperative to postoperative in all 3 groups (p-value< 0.0001) was observed. The VAS score initially improved equally in all three groups throughout the first three months following surgery, but after that, group I and group II patients recovered better than group III patients. The mean WOMAC score in group I pre-op was 36.2 and post-op at 1 year was 83.00, and in group II pre-op mean WOMAC score was 35.895 and post-op at 1 year 82.96, in group III pre-op mean WOMAC was 34 and post-op was 75.13 at 1 year. Knee society scores in groups I, II & III at Pre-op were 37.2, 38.33 & 38.45, and post-op at 1 year were 88.73, 84.63 & 80.64. The improvement in KSS value from pre-op and mean value was found to be statistically significant. The mean Functional knee society score of Group I, II& III at pre-op were 48.80, 50.50 & 42.82, and post-op at 1 year were 89.77, 86.87 &75.09 respectively. The mean score from the pre-op to post-operative period was statistically significant. The mean Objective knee society score of preoperative periods was 36.72, 37.25 & 32.27, and the postoperative period was 86.35, 85.38 & 75.73 at 1 year in groups I, II & III respectively, and found to be statistically significant.When the VAS score at different intervals from preoperative to post-operative periods at 3 months, 6 months, and 1 year was compared, all the three groups had significant findings up to 6 months follow-up, however, group III has insignificant findings at 6 months to the one-year interval. (Table 1)

Table 1: Comparisons of Mean VAS Score at different intervals from preoperative to postoperative period at 3 months, 6 months, and 1 year

VAS score			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	3.150	0.105	0.000*
		6 Months	5.075	0.110	0.000*
		1 Year	6.000	0.113	0.000*
	3 Months	6 Months	1.925	0.066	0.000*
		1 Year	2.850	0.067	0.000*
	6 Months	1 Year	0.925	0.042	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	3.167	0.143	0.000*
		6 Months	5.167	0.115	0.000*
		1 Year	6.208	0.134	0.000*
	3 Months	6 Months	2.000	0.104	0.000*
		1 Year	3.042	0.073	0.000*
	6 Months	1 Year	1.042	0.095	0.000*
Group III (>6°) n=11	Pre OP	3 Months	3.364	0.203	0.000*
		6 Months	5.273	0.195	0.000*
		1 Year	5.364	0.203	0.000*
	3 Months	6 Months	1.909	0.091	0.000*
		1 Year	2.000	0.234	0.000*
	6 Months	1 Year	0.091	0.251	1.000

The mean difference of WOMAC score at different intervals the data obtained was compared and found statistically significant in the initial 6 months in all three groups except in group III from 6 months to 1 year interval which is insignificant. (Table 2)

Table 2: Comparison of WOMAC score at different intervals from preoperative to post-operative periods at 3 months, 6 months, and 1 year

WOMAC Score			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-22.990	0.513	0.000*
		6 Months	-40.175	0.613	0.000*
		1 Year	-46.797	0.623	0.000*
	3 Months	6 Months	-17.185	0.524	0.000*
		1 Year	-23.807	0.465	0.000*
	6 Months	1 Year	-6.622	0.455	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-23.466	0.698	0.000*
		6 Months	-40.436	0.743	0.000*

		1 Year	-47.070	0.685	0.000*
	3 Months	6 Months	-16.970	0.717	0.000*
		1 Year	-23.604	0.541	0.000*
	6 Months	1 Year	-6.635	0.706	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-23.531	0.904	0.000*
		6 Months	-37.571	1.014	0.000*
		1 Year	-40.761	2.890	0.000*
	3 Months	6 Months	-14.040	1.114	0.000*
		1 Year	-17.230	2.590	0.001*
	6 Months	1 Year	-3.190	3.201	1.000

Pre-op means flexion in Group I; II & III was 106.25, 108.96 & 113.18, and post-op at 1 year was 115.75, 116.25 & 113.64 respectively. We found an improvement in mean knee flexion was statistically significant (p-value <0.0001). The mean value of the Kujala score in groups I, II & III preoperative were 29.70, 30.08 & 29.18, and postoperatively at 1 year were 78.55, 79.63 & 75.18 respectively. Statistical improvement in score from pre-op to post-op in all 3 groups (p-value <0.0001) was observed. The mean values of Feller patellar score at preop in all 3 groups were 16.30,1 6.62 & 16.55 and postoperatively at 1 year was 26.2, 26.21 & 22.82 respectively. There was a significant improvement in score from preop to postoperatively and the p value was significant (<0.0001). The Mean Oxford knee score of all 3 groups was 15.35, 15.42 & 15.09, and postoperatively at 1 year were 44.02,42.54 & 39.82 respectively. There was a significant improvement in scores from preop to post-operative in all 3 groups and data is statistically significant.
There was statistical significance in all three groups in the forgotten score (FJS) at all time intervals. (Table 3)

Table 3: Comparisons of FJS at different intervals from preoperative to post-operative periods at 3 months, 6 months, and 1 year

Forgotten Joint Score			**Mean difference**	**Std. Error**	**p-value**
Group I (<3.0°) n=40	3 Months	6 Months	-17.740	0.471	0.000*
		1 Year	-24.420	0.517	0.000*
	6 Months	1 Year	-6.680	0.372	0.000*
Group II (3.0-6.0°)	3 Months	6 Months	-17.783	0.521	0.000*
		1 Year	-24.100	0.649	0.000*
	6 Months	1 Year	-6.317	0.426	0.000*
Group II (3.0-6.0°) n=24	3 Months	6 Months	-13.127	1.220	0.000*
		1 Year	-17.291	2.462	0.000*
	6 Months	1 Year	-4.164	2.963	0.000*

There was a statistically significant value (p=0.00) of knee society score (KSS) at different intervals in all 3 groups. (Table 4)

Table 4: Comparison of KSS at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

KSS			**Mean difference**	**Std. Error**	**p-value**
Group I (<3.0°) n=40	Pre OP	3 Months	-28.500	0.652	0.000*
		6 Months	-40.050	0.568	0.000*
		1 Year	-51.525	0.715	0.000*
	3 Months	6 Months	-11.550	0.642	0.000*
		1 Year	-23.025	0.795	0.000*
	6 Months	1 Year	-11.475	0.694	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-27.458	0.732	0.000*
		6 Months	-39.833	1.019	0.000*
		1 Year	-46.292	0.937	0.000*
	3 Months	6 Months	-12.375	0.766	0.000*
		1 Year	-18.833	0.942	0.000*
	6 Months	1 Year	-6.458	0.794	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-25.909	1.846	0.000*
		6 Months	-36.000	1.300	0.000*
		1 Year	-42.182	1.110	0.000*

	3 Months	6 Months	-10.091	1.449	0.000*
		1 Year	-16.273	1.251	0.000*
	6 Months	1 Year	-6.182	0.913	0.000*

There is a statistically significant improvement in mean functional knee society score (FKSS) in all three groups from pre-op to post-operative period however in group III after 6 months to 1-year duration and p value was not statistically significant (p value =1.00). (Table 5)

Table 5: Comparison of FKSS at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

FKSS			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-11.450	0.988	0.000*
		6 Months	-30.700	1.226	0.000*
		1 Year	-40.975	1.298	0.000*
	3 Months	6 Months	-19.250	1.067	0.000*
		1 Year	-29.525	1.266	0.000*
	6 Months	1 Year	-10.275	0.876	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-8.875	1.655	0.000*
		6 Months	-28.250	1.421	0.000*
		1 Year	-36.375	1.351	0.000*
	3 Months	6 Months	-19.375	1.098	0.000*
		1 Year	-27.500	1.467	0.000*
	6 Months	1 Year	-8.125	1.076	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-11.727	2.573	0.005*
		6 Months	-28.455	2.560	0.000*
		1 Year	-32.273	4.760	0.000*
	3 Months	6 Months	-16.727	2.212	0.000*
		1 Year	-20.545	5.135	0.015*
	6 Months	1 Year	-3.818	4.987	1.000

We compared the mean objective knee society score (OKSS) at different intervals, and we found a statistical significance (p-value < 0.05) in Group I and Group II value and no significance in Group III from 6 months to 1-year intervals. (Table 6)

Table 6: Comparison of Mean OKSS at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

OKSS			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-24.375	1.878	0.000*
		6 Months	-40.275	1.583	0.000*
		1 Year	-49.625	1.580	0.000*
	3 Months	6 Months	-15.900	0.688	0.000*
		1 Year	-25.250	1.072	0.000*
	6 Months	1 Year	-9.350	0.836	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-24.583	1.923	0.000*
		6 Months	-40.167	1.730	0.000*
		1 Year	-48.125	1.794	0.000*
	3 Months	6 Months	-15.583	0.764	0.000*
		1 Year	-23.542	0.969	0.000*
	6 Months	1 Year	-7.958	0.861	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-29.909	4.408	0.000*
		6 Months	-45.455	3.937	0.000*
		1 Year	-43.455	5.338	0.000*
	3 Months	6 Months	-15.545	0.976	0.000*
		1 Year	-13.545	4.646	0.093
	6 Months	1 Year	2.000	4.425	1.000

On comparison of flexion at different groups, the data obtained was statistically insignificant that is p value > 0.05. (Table 7)

Table 7: Comparison of Total Range of Flexion (TROM) at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

TROM			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	23.750	2.213	0.000
		6 Months	3.125	1.900	0.649*
		1 Year	-9.500	1.841	0.000
	3 Months	6 Months	-20.625	1.281	0.000
		1 Year	-33.250	1.786	0.000
	6 Months	1 Year	-12.625	1.074	0.000
Group II (3.0-6.0°) n=24	Pre OP	3 Months	25.000	3.548	0.000
		6 Months	4.375	2.876	0.851*
		1 Year	-7.292	2.407	0.036
	3 Months	6 Months	-20.625	1.788	0.000
		1 Year	-32.292	2.407	0.000
	6 Months	1 Year	-11.667	1.433	0.000
Group III (>6°) n=11	Pre OP	3 Months	28.636	5.049	0.001
		6 Months	7.273	5.281	1.000*
		1 Year	-0.455	4.741	1.000*
	3 Months	6 Months	-21.364	2.344	0.000
		1 Year	-29.091	3.221	0.000
	6 Months	1 Year	-7.727	2.170	0.031

In a comparison of Kujala scores at different intervals we found statistical improvement in scores in all 3 groups (p=<0.05). (Table 8)

Table 8: Comparison of Kujala Score at different intervals from preoperative to post-operative periods at 3 months, 6 months, and 1 year

Kujala score			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-24.800	0.810	0.000*
		6 Months	-38.550	0.856	0.000*
		1 Year	-48.850	0.578	0.000*
	3 Months	6 Months	-13.750	0.855	0.000*
		1 Year	-24.050	0.679	0.000*
	6 Months	1 Year	-10.300	0.639	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-26.083	1.068	0.000*
		6 Months	-39.167	0.770	0.000*
		1 Year	-49.542	0.730	0.000*
	3 Months	6 Months	-13.083	0.919	0.000*
		1 Year	-23.458	0.901	0.000*
	6 Months	1 Year	-10.375	0.855	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-26.091	1.239	0.000*
		6 Months	-34.545	0.767	0.000*
		1 Year	-46.000	1.183	0.000*
	3 Months	6 Months	-8.455	1.155	0.000*
		1 Year	-19.909	1.171	0.000*
	6 Months	1 Year	-11.455	0.878	0.000*

The mean value of the feller patellar score (FPS) in all 3 groups compare at different intervals there is a significant improvement in all 3 groups (p value <0.05). The mean value of the feller patellar score is independent of the individual group. (Table 9)

Table 9: Comparison of Mean FPS at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

FPS			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-2.950	0.182	0.000*
		6 Months	-6.500	0.238	0.000*

		1 Year	-9.925	0.191	0.000*
	3 Months	6 Months	-3.550	0.248	0.000*
		1 Year	-6.975	0.204	0.000*
	6 Months	1 Year	-3.425	0.175	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-3.125	0.271	0.000*
		6 Months	-6.375	0.323	0.000*
		1 Year	-9.583	0.255	0.000*
	3 Months	6 Months	-3.250	0.243	0.000*
		1 Year	-6.458	0.233	0.000*
	6 Months	1 Year	-3.208	0.208	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-2.273	0.359	0.001*
		6 Months	-3.909	0.285	0.000*
		1 Year	-6.273	0.273	0.000*
	3 Months	6 Months	-1.636	0.364	0.007*
		1 Year	-4.000	0.426	0.000*
	6 Months	1 Year	-2.364	0.203	0.000*

The mean value of Oxford knee score (OKS) was compared at a different interval from pre-op to post-operatively between all 3 groups is statistically significant and has improvement at different intervals (p value=0.000). (Table 10)

Table 10: Comparison of OKS at different intervals from preoperative to post-operative period at 3 months, 6 months, and 1 year

OKS			Mean difference	Std. Error	p-value
Group I (<3.0°) n=40	Pre OP	3 Months	-10.050	0.351	0.000*
		6 Months	-18.625	0.341	0.000*
		1 Year	-28.675	0.346	0.000*
	3 Months	6 Months	-8.575	0.336	0.000*
		1 Year	-18.625	0.357	0.000*
	6 Months	1 Year	-10.050	0.391	0.000*
Group II (3.0-6.0°) n=24	Pre OP	3 Months	-10.125	0.368	0.000*
		6 Months	-19.167	0.379	0.000*
		1 Year	-27.125	0.464	0.000*
	3 Months	6 Months	-9.042	0.533	0.000*
		1 Year	-17.000	0.496	0.000*
	6 Months	1 Year	-7.958	0.615	0.000*
Group III (>6°) n=11	Pre OP	3 Months	-10.727	0.524	0.000*
		6 Months	-19.273	0.905	0.000*
		1 Year	-24.727	0.574	0.000*
	3 Months	6 Months	-8.545	0.705	0.000*
		1 Year	-14.000	0.603	0.000*
	6 Months	1 Year	-5.455	0.743	0.000*

Discussion:

The ability for achieving maximum ROM after total knee arthroplasty is impacted by a various factor. The surgeon has some control over some of these factors. Others, such as preoperative ROM, are out of the surgeon's control. According to hypothesis of some of the authors, the proximal tibial slope may affect postoperative range of motion. In a computer modelling study, Walker and Garg attempted to determine the proximal tibial slope effect on postoperative range of motion.Furthermore, the study compared the results of a 108-posterior tilt, a neutral tilt, and a 108-anterior tilt. It was observed that a 108 posterior tilt yielded an increase of at least 308 in flexion compared to the neutral tilt, whereas the anterior tilt had the opposite impact. While these outcomes are anticipated in a computer simulation, it's possible that the model may have neglected certain important anatomical and physiological factors. undoubtedly, the in vivo scenario differs substantially from the analytical computer modelling due to the presence of confounding variables.[9]Numerous studies have examined the influence of altering the posterior tibial slope (PTS) angle on the range of motion in fixed total knee prostheses.[10] A cadaver study by Chambers et al. found that a gradual increase in tibial inclination up to 10 degrees produced a gradual increase in degrees of flexion up to 10.6 degrees.[11] Other biomechanical studies also showed that increasing tibial inclination increased joint range of motion.[12] In comparison to the fixed-bearing TKA, the mobile bearing design has biomechanical differences that have an impact on the postoperative range of motion. There are not many studies evaluating the influence of changing PTS on range of motion in mobile bearing total knee prosthesis. Kastner et al. conducted a study examining the impact of posterior tibial slope (PTS) on range of motion (ROM) following low contact motion-bearing total knee arthroplasty (TKA) and their findings indicated that there was no correlation between tibial inclination and ROM.[13] In our study, based on the clinical data analysis, there were statistical differences between the groups in terms of VAS and WOMAC score. Group I and Group II had better VAS, WOMAC score, functional knee society score, and objective knee society score compared to Group III which is statistically significant. Forgotten score, knee society score, functional knee society score, and objective knee society score improved in all three groups with statistically significant. The WOMAC score was statistically and significantly reduced from the preoperative to the postoperative period at different time intervals. The Kujala score, Feller patellar score, and Oxford knee score demonstrated improvement in each group across different time intervals from preoperative to postoperative phases. Also, a statistically significant difference was observed between the groups. The change in PTS angle alters the femur-tibia contact point in the sagittal plane and affects the biomechanics of the patella and quadriceps. [12] Following knee arthroplasty, alterations in the joint line lead to adjustments in the resting position of the patella's height. Moreover, changes in the mechanical axis within the coronal plane bring about modifications in the patella-Q angle. The extent of patellar height change can give rise to indications of patellar malalignment, subluxation, patellar chondromalacia, and anterior knee pain.The design of the mobile insert has biomechanical properties close to those of the normal knee joint. Both anterior-posterior translation and internal-external rotation occur at the interface of the insert with the tibial shell. The larger contact area and load distribution in these designs result in better compensation for mechanical axis changes.[14] The clinical evaluation we conducted using different knee scores showed that there was a substantial difference between the groups based on the knee scores.There may be differences in normal posterior tibial tilt and lateral and medial tibial plateau tilt depending on race and gender. In a study, Jade Pei Yuik Ho et al. showed that in Asian knees, the average PTS is 11°, with a reference range of 5°-17° (mean ±2 standard deviation).[15] The average posterior tilt of the medial plateau was determined to be 14.8° in the study by Chiu et al., whereas the average posterior tilt of the lateral plateau remained 11.8°.[16] Those outside the range of 5–10 degrees were included in the study by considering the average reference values of the PTS angle. For tibial implants, a tibial slope of 5 and 10 degrees has been accepted as lower and upper limits in literature. Ken Okazaki et al. accepted the inclination angle of 5 degrees as a reference value. Wittenberg et al. stated that 0–10 degrees can be considered normal. Keong-Hwan Kim et al. found that a difference of 4 degrees was significant in his study. Wittenberg et al. also used measurements with a difference of 5 degrees in their studies.[17-19]In the present study, there was a statistically significant difference in the pre-and postoperative changes in the different knee scores among the 3 groups that were divided according to the changes in the pre-and postoperative PTS. We attributed this to the fact that most of the patients had degenerative arthritis and PTS is not the only factor that influences postoperative pain, ROM limitation, and knee function. PTS increase and PCL release in TKA contribute to the improvement of flexion tightness. The latter corrects anteroposterior tightness, whereas the former enhances varus and valgus, anteroposterior, and rotational laxity in knees that are too tight in flexion. Therefore, PTS increase can be more effective than PCL release in the knees with abnormal collateral ligament tightness and flexion tightness.[19] Walker and Garg reported that a 30o increase in flexion was observed in the knees with 10o PTS compared to those with 0o PTS after PCL-retaining TKA.[9] In a cadaver study by Bellemans et al., flexion improved by 1.7º for every 1o extra PTS.[4] We think that our study results should be confirmed by future clinical and biomechanical studies with prospective design and tighter control on possible confounding variables.The current study showed that the postoperative TROM had a correlation with the degree of change in PTS following TKA. After a TKA, achieving a satisfactory ROM is thought to be an important criterion for success.[20] According to surgeons, a variety of factors, including preoperative ROM, BMI, prosthesis design, PTS, and surgical methods, might determine whether or not a patient achieves their maximum ROM after TKA. According to several research, the postoperative PTS affects the postoperative ROM in cruciate retaining (CR) type TKAs.[21] The PTS in the sagittal plane has been demonstrated by Walker and Garg to be the most significant surgical variable in relation to postoperative maximal flexion.[6] In addition, Bellemans et al. demonstrated that an increase in PTS of 1° resulted in a 1.7° improvement in maximal flexion.[4] Multivariate regression analysis of a clinical study with CR TKA demonstrated a significant correlation among PTS as well as postoperative ROM at 12 months of follow-up (p 0.001).[4] According to several studies, postoperative flexion angle after PS TKA, as in cruciate-retaining TKA, has been associated to an elevated PTS.[22] Shi et al. performed indeed show a positive association, reporting that following PS TKA, the maximal knee flexion increased by 1.8° for every degree that the PTS increased.[5] Additionally, in a study of 167 patients (209 TKAs), which is consistent with the current study, the absolute difference between post- and preoperative PTS was substantially connected with postoperative flexion (p 0.001).[22] However, other research has denied the association between ROM and postoperative PTS.[23] After either PS TKA or CR TKA, Oka et al. revealed that there was no association between the PTS and maximum knee flexion.[23] Kansara and Markel found no significant difference in knee flexion after PS TKA.[24] It is controversial how the PTS affects the postoperative maximal flexion in PS TKA because the kinematics of knee flexion in PS TKA differ from those in CR TKA.[25] Additionally, Bauer et al observed that, following PS TKA, there was no connection between PTS and maximum knee flexion.[26] Between a group of patients with a mean PTS of 1.8 degrees as well as a group of patients with a mean PTS of 5.5 degrees, An early cam-post impingement in full extension may result from a tibial component with elevated PTS.[26] Furthermore, according to several of studies on the impact of posterior cruciate ligament (PCL) resection on flexion-extension gaps during TKA, the flexion gap is increased by 3 to 5 mm while the extension gap is only increased by 1 mm following PCL resection.[27] Theoretically, using a thicker PE insert to close the flexion gap could prevent full extension without additional distal femur resection as well as worsen the range of motion after surgery.[28] In order to reduce the flexion gap in PS TKA, efforts must be made to reduce the PTS.17 Instead, a decrease in PTS brought on by a more significant shift in PTS may impair movement effectiveness and result in a decrease in quadriceps force and patellofemoral contact force.[29] A decreased level in PTS results in a decrease in the quadriceps lever arm because it causes the tibial component to move to a more posterior position and the femoral and tibial components to make contact at an anterior position. Therefore, when engaging in activities that require for greater strength from the quadriceps muscle, such getting up from a chair or climbing stairs, reducing the PTS may demand more quadriceps effort and patellofemoral contact force. In order to determine the impact of changes in the PTS on postoperative activities, such as getting up from a chair and climbing stairs, more research is needed. As a result, it is unclear whether an amount of change in PTS influences postoperative clinical scores. An excessive posterior slope caused anterior postcam impingement in PS TKA.[30] Based on a computer simulation, a recent article suggested that the posterior tibial slope should be lesser than 5°.12 Additionally, the study found that when the posterior slope of the tibia exceeded 5°, abnormal kinematics, such as anterior sliding of the tibial component and anterior impingement of the tibial post, were observed, supporting the idea that an excessive posterior slope of the tibia in a PS knee must be avoided to prevent damage to a post-cam mechanism. Some research investigated into the relationship between the post-operative flexion angle and also the posterior tibial slope for PS TKA. According to previous research, the posterior slope increased by 1.8° per degree, improving the flexion angle.[31] However, a different study found no changes between the two groups' post-operative range of motions following the use of a cutting block tilted at 0° and 5°, respectively.24 Another study found that the post-operative range of motion did not significantly differ between the groups having a posterior slope of less than 10° and ≥ 10°.[32] These investigations were observational in nature, making it impossible to rule out factors other than the posterior tibial slope from having an impact on the post-operative flexion angle. Due to the great conformance of the insert to the femoral component in this investigation, the effect of the shift might be obscured. High flexion was associated with considerable internal tibial rotation, which suggests that the rotational freedom had an impact on the flexion angle.[33] Clinical evidence suggests that patients are particularly concerned in stability when walking and climbing stairs, that is, flexion of up to 70-110 °. Although a greater range of motion in patients with a higher PTS has been found in MS designs, better functional outcomes (WOMAC) were found in patients with a lower PTS (<5°).33 Likewise, the literature shows that a very large PTS should be avoided due to the lack of stability resulting from the inclined plane and ligament changes during mid-flexion.This study demonstrated a significant difference between the <3°, 3-6 ° and >6 ° groups at three, six, and twelve months in either range of motion or patient-reported outcome measures. By facilitating femoral roll-back, which varies between medial and also lateral sides, and by keeping strain on the posterior cruciate ligament, the posterior tibial plateau slope contributes significantly to the biomechanics of the knee joint.[34] Although there is ongoing discussion, cruciate-retaining implants maintain some femoral roll-back because of the tension on the posterior cruciate ligament. This results in normal knee kinematics. Accordingly, a posterior tibial slope should increase the flexion gap and maximize flexion in cruciate-retaining implants. After increasing the tibial slope from 0 to 4 degrees, Bellemans et al.'s cadaveric investigation demonstrated significant improvements in maximal flexion (104 to 112 degrees). This group also demonstrated that the main obstruction to greater flexion in a cruciate-retaining knee was impingement of the rear of the femur on the tibial baseplate.[4] Yet to date these improvements in flexion have not been replicated in clinical studies nor related to improved patient-reported outcomes.[32] In a retrospective analysis of 801 knees, Seo et al. found that patients with a tibial slope between 3° and -1° had significantly better Kujala and Feller patella scores, yet no significant movement improvement.[35] Other retrospective clinical studies looking at both cruciate-retaining and posterior stabilized knee implants have failed to show a difference in either movement or patient outcome.[36] Our results showed improved flexion or patient outcome with a posterior tibial slope between the three groups. The utilization of the proximal tibial anatomical axis was adopted due to its demonstrated accurate correlation with the tibial mechanical axis, justifying its application as a measurement technique.[37] Ismalilidis et al published research proposes that variations in posterior tibial slope should not contribute to rotational malalignment if the arthroplasty is aligned using the anatomical tibial axis as a reference.[38] Proposing an alternative approach, it has been suggested that aligning the tibial slope parallel to the physiological preoperative slope, rather than adhering to a pre-determined angle, can potentially yield enhanced soft tissue balancing and a more "normal" knee kinematic pattern. Theoretically, this should lead to increased flexion. Nevertheless, our study did not uncover a significant distinction in flexion among subgroups with comparable body mass index. This observation could potentially be elucidated by Nagamine's study, which demonstrated that among 208 patients undergoing total knee replacement, approximately 86.5% of patients did not exhibit a posterior slope in the proximal tibial condyle.[39] The study has few limitations. The investigation was only carried out at a railway hospital, and the sample size was limited. Better functional scores must be assessed over a longer follow-up by conducting a study in multi-centres.

Conclusion:

The amount of change in PTS improved the postoperative clinical knee scores even though proximal tibial resection with a consistent target of PTS led to individually variable variations in the PTS after PS TKA. Drawing from our findings, we can recommend a posterior tibial slope (PTS) of less than 3° or between 3° and 6° for the total knee arthroplasty (TKA) employed in this study. In order to explore the impact of the PTS during alignment, it would also be interesting to look at the effect of the alignment methodology while using the newer kinematic alignment.

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