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Original Research Article

POST-OPERATIVE RADIOLOGICAL ASSESSMENT OF POSTERIOR TIBIAL SLOPE AND IT'S INFLUENCE ON FUNCTIONAL OUTCOME AFTER TOTAL KNEE ARTHROPLASTY

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Abstract

Total knee arthroplasty (TKA) is an effective treatment for advanced knee joint disorders that restores knee function and improves quality of life. PTS is one of the most important contributing factor affecting the post TKA knee ROM and functional outcome, though it's influence has long been debatable in PS TKA.
In this study we aimed to observe the difference between pre-op vs post-op PTS and it's influence on post-operative functional outcome & knee ROM.
27 Knees (14 male,13 female) were included in our study. Pre-op & post-op PTS were measured from true lateral knee radiograph. Knee Society Score (KSS) score was obtained by accessing functional ability and thorough knee examination. It was observed that PTS changed from 9.02±1.66 to 5.8±0.522. Maximum knee flexion increased from 86.85±10014 to110.93±7.6. KSS function score improved from 22.22±11.214 to 75.0±6.355.
Therefore, we recommend maintaining an optimal PTS of 5 to 6 degrees, as this has been shown to have a positive impact on postoperative knee flexion and overall functional result.

INTRODUCTION

Total knee arthroplasty (TKA) is a highly efficient surgical procedure used to treat high grade osteoarthritic knee. Its primary goal is to relive pain, restore natural knee joint function and enhance the quality of life for patients. However, over 20% of patients express dissatisfaction with the outcome of the surgery, primarily due to the inability to fully restore knee function following TKA. Bourne et al. found that patient satisfaction regarding function during the performance of daily living activities varied between 70 and 84%.[1]

The knee joint function is pursued by seeking restoration of normal mobility and stability at the replaced joint. The more natural kinematics of the knee, such as femoral external rotation and posterior translation during knee flexion, better is the functional outcome and satisfaction for the patient post-TKA.[2]

One of the key elements that impacts patient satisfaction and post-operative performance following total knee arthroplasty (TKA) is the maximal flexion angle. Numerous factors, such as the degree of deformity, surgical procedures, prosthesis type, and pre-operative flexion angle, posterior condylar offset influence the post-operative flexion angle.[3–6]

Measurement of the PTS has important applications in total knee arthroplasty (TKA), high tibial osteotomy (HTO), and anterior cruciate ligament (ACL) reconstruction surgery.[7] The posterior slope of the tibia is a possible and long debated factor that may affect the flexion gap.

In cruciate retaining(CR) TKA prosthesis, an increased PTS enhances post-TKA knee flexion by increasing tension over the PCL, known as the roll-back phenomenon as well as increasing the moment arm of the quadriceps muscles by shifting the tibiofemoral contact points posteriorly, which helps knee extension in weak quadriceps of osteoarthritic knee.[8–10]

But it is linked to increased contact pressure on the posterior face of the PE insert and the CAM-POST, which results in greater wear and tear as well as aseptic loosening.[9,11] However the influence of posterior tibial slope on the posterior-stabilized (PS) prostheses remains controversial. Though decreased PTS reduces the intra op flexion gap some studies showed there was no significant difference,[12] in

post PS-TKA knee ROM & functional outcome in long term follow up,[3,13,14] and few study showed increased post op PTS increase the post op maximal knee flexion with good functional outcome if gap balancing was done judiciously during TKA[1]. So a surgeon should be cautious when determining the PTS, as an inordinate increase in the PTS may result in the progressive loosening of the tibiofemoral joint as a result of a reduction in collateral ligament tension and the failure of the post in a PE insert. Consequently a more personalized optimal PTS determination is necessary before TKA.[9]

In our study we observe the post TKA PTS obtained by multiple surgeons & its influence on post operative knee rom & functional outcome

Aims & Objectives

Aim

To evaluate post-operative Posterior Tibial Slope and observe its influence on functional outcome after Total Knee Replacement surgery.

Objectives

1. To compare preoperative vs postoperative posterior tibial slope by true lateral plain radiograph of knee
2. To assess the influence of posterior tibial slope on postop range of motion of knee and assess the functional outcome by evaluating Knee Society Score (KSS).

MATERIALS AND METHODS

After getting permission from the ethical committee as well as satisfying all inclusion and exclusion criteria, we took a total 27 knees (14 male, 13 female underwent TKA at our hospital in 2022–23. It is a hospital based observational study.

Inclusion Criteria

- Patients of both sexes above 55 years & below 75 years
- Grade iii & iv osteoarthritis of knee joint
- BMI less than 28

Exclusion Criteria

- Arthritis due to traumatic or infective & inflammatory cause
- Revision surgeries
- ·Previously done ipsilateral hip arthroplasty
- Coronal plane malalignment(varus/valgus) less than 15 degrees

We performed a detailed clinical & radiological examination of the patient which included history, functional ability of the patient, thorough examination of knee, weight bearing AP radiograph & true lateral radiograph of flexed knee. We used KSS SCORE which is divided into 2 parts; a. knee score & b. function score

A. The Knee score (0/100)* is used to assess the pain status, range of motion, alignment ,medio-lateral & anteroposterior stability.
B. The function score (0/100)* is utilized to assess functional ability in terms of walking distance, utilization of walking aids, and ability to climb stairs.

(* - minimum score 0 , maximum score 100)

We used true lateral radiograph of knee to measure the posterior tibial slope (PTS) preoperative & post operatively.

Measurement of PTS

The posterior tibial slope (PTS) is the angle formed between the vertical line of the tibial anatomical axis and the tibial plateau tangent. PTS was obtained by measuring the angle that was formed between the horizontal line that was drawn perpendicular to the anatomical axis of the tibia and the line that was tangent to the anterior and posterior elements of the tibia medial plateau.[16,17]

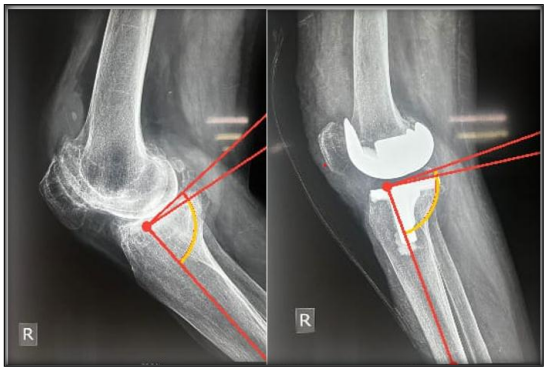

Figure 1: Preop & post of PTS measured 9 degree & 6 degree

Rehabilitation protocol

We followed a standard rehab protocol as post-operative physical therapy & rehabilitation greatly influence the functional outcome of the TKA18.

From post-op day 1 we started full weight bearing with support & long knee brace

From post-op day 2 knee ROM exercise was initiated actively or passively.

Sutures were removed at 14 days and quadriceps strengthening exercises were started & continued along with preoperative and postoperative data collection at a one-year follow-up.

For statistical analysis data was entered into a Microsoft excel spreadsheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Data was summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. Z-test (Standard Normal Deviate) was used to test the significant difference of proportions.

Explicit expressions that can be used to carry out various t-tests are given below. In each case, the formula for a test statistic that either exactly follows or closely approximates a t-distribution under the null hypothesis is given. Also, the appropriate degrees of freedom are given in each case. Each of these statistics can be used to carry out either a one-tailed test or a two-tailed test.

p-value $\leq$ 0.05 was considered for statistically significant.

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RESULTS

14 males & 13 females were included in our study in whom mean age, height, weight & BMI found to be 64.56 5.086, 169.9 6.382, 24.64 1.9253 respectively. Study showed a **decreased PTS** from preop 9.02±1.661 to post op 5.8±0.524

A **significant improvement** was seen in **KSS** score (**Knee Score** raised from 45.19± 8.652 to± 90.22 3.03 & **Function Score** from 22.2±11.294 to 75±6.355)

There was also **increased** post-operative **Knee Flexion** from 86.85±10.014 to 110.93±7.6 [Table 1]

Pre Op PTS - Post Op PTS (mean±s.d.) 1.739 ± 0.335. It was found to be statistically significant <0.0001

KSS KNEE score –

Pre op - Post Op KSS(mean±s.d.) 9.242 ± 1.779. It was statistically significant <0.0001

Preop KSS FUNCTION Score –

Preop- Post of Kss-Function(mean±s.d.) 11.123 ± 2.141. It was statistically significant <0.0001

Pre Op Knee Flexion - Post -Op Knee Flexio(mean±s.d.) 7.473 ± 1.438. It was statistically significant < 0.0001. [Table 2]

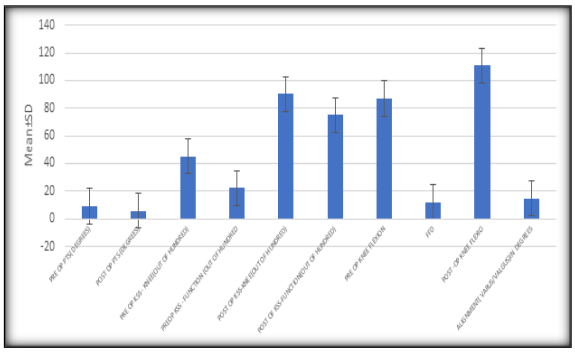

Figure 2: Mean ±SD of Study Variables; Pre-Op & Post –Op

Figure 2: Improved post op knee flexion

Table 1: Frequency of Mean of Study Variables

Demographics	Minimum	maximum	Mean ±sd
Age	56	74	64.56±5.086
Height	158	184	169.9±6.382
Weight	55	84	71.30±8.507
BMI	21.0	28.3	24.64±1.9253

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
PRE OP PTS	27	6	12	9.02	1.661
POST OP PTS	27	5	7	5.8	0.524
PRE OP KSS – KNEE	27	29	55	45.19	8.652
PREOP KSS - FUNCTION	27	10	45	22.22	11.294
POST OP KSS-KNEE	27	81	94	90.22	3.03
POST OF KSS-FUNCTION	27	55	80	75	6.355
PRE OP KNEE FLEXION	27	65	100	86.85	10.014
FFD	7	10	15	12.14	2.673
POST -OP KNEE FLEXION	27	95	120	110.93	7.6

Table 2: Comparison of Preop Vs Post Op PTS, KSS, KNEE ROM

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PRE OP PTS - POST OP PTS	3.222	1.739	0.335	2.534	3.91	9.626	26	<0.0001
Pair 2	PRE OP KSS - KNEE- POST OP KSS-KNEE	-45.037	9.242	1.779	-48.693	-41.381	-25.32	26	<0.0001
Pair 3	PREOP KSS - FUNCTION - POST OF KSS-FUNCTION	-52.7	11.123	2.141	-57.178	-48.378	-24.6	26	<0.0001

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		78					56		
Pair 4	PRE OP KNEE FLEXION - POST -OP KNEE FLEXIO	-24.074	7.473	1.438	-27.03	-21.118	-16.74	26	<0.0001

DISCUSSION

Postoperative range of motion (ROM) is recognized to have an impact on patient satisfaction following total knee arthroplasty (TKA), since it enhances postoperative function and contentment. Some authors observed that the posterior tibial slope (PTS) linked with postoperative ROM following total knee arthroplasty (TKA), among numerous parameters impacting postoperative ROM, including sex, age, preoperative ROM, body mass index (BMI), prosthesis design, and surgical procedures.[19] It has long been known that improved flexion following total knee arthroplasty (TKA) is correlated with higher PTS. As a result, a lot of manufacturers included the angle of the postoperative tibial resection and a built-in PTS while designing the whole knee prosthesis. Regarding an elevated PTS after posterior cruciate-substituting (PS) TKA, there are numerous worries. In fact, several investigations have demonstrated that maximal flexion is not aided by the elevated PTS in PS TKA.[20]

Increased PTS may raise the possibility of the polyethylene insert wearing out and causing cam-post impingement20. So we had carried out our study to know the effect of optimum PTS on functional outcome and range of motion post TKA.

After a TKA, achieving enough range of motion is thought to be crucial to the procedure's success. Surgeons think that a variety of factors, including surgical procedures, BMI, prosthesis design, PTS, and preoperative range of motion, influence achieving maximal range of motion following total knee arthroplasty. In our study, we had used PS implant (DePuy , Smith and Nephew) similar to the study conducted by Lee et al.[13] Although the effect of demographical data like BMI age , sex were not evaluated per se. In our study the mean preop PTS was 9.02 ± 1.661 which was changed to 5.8 ± 0.524 post TKR. similar to that of the study conducted by Lee et al13 in which the preop PTS was 9.6±3.4 which was changed to 2.0±1.3. The mean change of PTS came out to be 3.22± 1.141. This highlights the fact that the altered post op PTS might point towards the different patient demography & instrument constraints. The pre-op ROM (Flexion) in our study was 86.85±10.014; after TKA, it changed to 110.93±7.6 at the 6-month follow-up, showing a significant difference of 24.08±2.414. In contrast, the study by Lee et al. showed a difference of only 1.7±3.3 at the 1-year follow-up, changing from 126.9±13.0 to 128.6±9.7.

The difference in this aspect lies in the fact that the preoperative selection of patients with different range of motion along with the difference in follow up period of 6 months and 1 year between the two studies.

Walker and Garg believed that increasing the tibial slope in total knee arthroplasty (TKA) was beneficial with regard to maximal postoperative flexion. Review of the clinical literature, however, does not confirm this hypothesis, neither does it give an answer to the question of how much flexion gain can be expected per degree extra tibial slope.

In a cadaver study by Bellemans et al,[21] flexion improved by 1.7 degree for every 1degree extra PTS. Although in our study, we did not do any correlation between the degree of change of PTS with ROM. Nonetheless, a number of research investigations have refuted the link between ROM and postoperative PTS.[21] In fact, following either PS TKA or CR TKA, Oka et al,[12] discovered that there was no association between the PTS and maximal knee flexion.[12]

Furthermore, following PS TKA, Bauer et al.[22] found no association between PTS and maximal knee flexion. Between a group of patients with a mean PTS of 1.8 degrees and a group of patients with a mean PTS of 5.5 degrees, Kansara and Markel found no statistically significant change in knee flexion following PS TKA Kansara and Markel,[14] discovered no statistically significant difference in the clinical outcome measured by KSS between a group of 30 PS TKAs with a PTS of 5 degrees and a group of 31 instances PS TKAs with a PTS of 0 degrees with regard to the impact of postoperative PTS on clinical outcomes.[14]

In their study, Lee and colleagues13 found that patients who experienced a greater change in PTS following PS TKA had more trouble "rising from sitting (WOMAC function, No 10)" and were more conscious of their knees "when climbing stairs (the Forgotten Joint Score, No. 6). It has been demonstrated that a decrease in the maximum quadriceps force and patellofemoral contact force is associated with an increase in PTS.[23] Conversely, a decrease in PTS brought on by a more significant shift in PTS may hinder movement efficiency, which in turn may result in a decrease in the force produced by the quadriceps and the patellofemoral contact force.[24]

The tibial component positions itself more posteriorly and the femoral and tibial components make greater anterior contact when the PTS is reduced.

Patellar height could vary depending on the size and positioning of the patellar prosthesis, in addition to other surgical variables like as the postoperative PTS. This may effect the clinical outcome of functional scoring done. The fact that we didn't include these biomechanics in our study may be considered as one of our limitations and further studies in this aspect are needed to give a more robust understanding of this arena.

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Seo and colleagues11 in their study found out that the group of patients with PTS more than 3 degree had KSS functional score of 53.4+/- 14.2 which increased to 82.4+/- 1.5 and KSS knee score of 55.8+/-2.14 which increased to 86.3 +/- 8.2.

Similarly in our study , we found out that the KSS functional score was changed to 75 +/-6.35 from 22.2 +/- 11.29 and KSS knee score was changed to 90.22 +/-3.03 from 45.19+/-8.65. The improvement in KSS functional score was not that much in our case although it being statistically significant. This may be attributed to the femur's posterior translation with respect to the tibia, which causes the patellar tendon to get impinged upon or experiences excessive traction stresses on it during joint movement. Furthermore, there was not a single instance of tibial component loosening in our investigation, defying our hypothesis that PTS is associated with a higher incidence of loosening because of increased strain on the posterior compartment during flexion. The postoperative outcomes of PTS, Range of Motion, KSS came out to be statistically significant in our study further strengthening the fact that optimum PTS may lead to good functional and biomechanical outcome after TKA.

Limitation

1. Posterior condylar offset was not measured in our study which also had a great impact on post op knee flexion.
2. We had done only PS-TKA in our study.
3. Stratification of posterior tibial slope could not be done due to instrumentation constraints
4. The surgery was performed by multiple surgeons
5. The effects of patients demographics like age & BMI might alter the functional assessment

CONCLUSION

Though few study showed that no relation between post-operative tibial slope with post op knee flexion and functional outcome; some study shows increased PTS provides more post-operative knee flexion in cost of increased implants wear & tear & aseptic loosening in long term follow up, we concluded our study by observing that keeping optimum posterior tibial slope will result in better functional outcome in terms of improvement in KSS score & post-operative knee flexion in PS-TKA.

REFERENCES

1. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop. 2010 Jan;468(1):57–63.
2. Wang Y, Yan S, Zeng J, Zhang K. The biomechanical effect of different posterior tibial slopes on the tibiofemoral joint after posterior-stabilized total knee arthroplasty. J Orthop Surg. 2020 Aug 12; 15:320.
3. Takemura S, Ikawa T, Ohyama Y, Kim M, Takaoka K, Minoda Y, et al. The posterior tibial slope does not influence the flexion angle in posterior-stabilized mobile-bearing total knee arthroplasty. Arthroplasty. 2021 Aug 2; 3:28.
4. Sultan PG, Most E, Schule S, Li G, Rubash HE. Optimizing Flexion After Total Knee Arthroplasty: Advances in Prosthetic Design. Clin Orthop Relat Res. 2003 Nov; 416:167.
5. Malviya A, Lingard EA, Weir DJ, Deehan DJ. Predicting range of movement after knee replacement: the importance of posterior condylar offset and tibial slope. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2009 May;17(5):491–8.
6. Han HS, Kang SB. Interactive effect of femoral posterior condylar offset and tibial posterior slope on knee flexion in posterior cruciate ligament-substituting total knee arthroplasty. The Knee. 2018 Mar;25(2):335–40.
7. Ahmad R, Patel A, Mandalia V, Toms A. Posterior Tibial Slope: Effect on, and Interaction with, Knee Kinematics. JBJS Rev. 2016 Apr 12;4: e3–e3.
8. Giffin JR, Vogrin TM, Zantop T, Woo SLY, Harner CD. Effects of increasing tibial slope on the biomechanics of the knee. Am J Sports Med. 2004 Mar;32(2):376–82.
9. Kang KT, Kwon SK, Son J, Kwon OR, Lee JS, Koh YG. The increase in posterior tibial slope provides a positive biomechanical effect in posterior-stabilized total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2018 Oct;26(10):3188–95.
10. Guo N, Smith CR, Schütz P, Trepczynski A, Moewis P, Damm P, et al. Posterior tibial slope influences joint mechanics and soft tissue loading after total knee arthroplasty. Front Bioeng Biotechnol. 2024; 12:1352794.
11. Seo SS, Kim CW, Kim JH, Min YK. Clinical Results Associated with Changes of Posterior Tibial Slope in Total Knee Arthroplasty. Knee Surg Relat Res. 2013 Mar;25(1):25–9.
12. Oka S, Matsumoto T, Muratsu H, Kubo S, Matsushita T, Ishida K, et al. The influence of the tibial slope on intra-operative soft tissue balance in cruciate-retaining and posterior-stabilized total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2014 Aug;22(8):1812–8.
13. Lee OS, Lee J, Lee MC, Han HS. Effect of Posterior Tibial Slope Change on Postoperative Range of Motion and Clinical Outcomes after Posterior Cruciate-Substituting Total Knee Arthroplasty. J Knee Surg. 2023 Jan;36(1):87–94.
14. Kansara D, Markel DC. The Effect of Posterior Tibial Slope on Range of Motion After Total Knee Arthroplasty. J Arthroplasty. 2006 Sep 1;21(6):809–13.
15. Shi X, Shen B, Kang P, Yang J, Zhou Z, Pei F. The effect of posterior tibial slope on knee flexion in posterior-stabilized total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2013 Dec;21(12):2696–703.
16. Chen Y, Ding J, Dai S, Yang J, Wang M, Tian T, et al. Radiographic measurement of the posterior tibial slope in normal Chinese adults: a retrospective cohort study. BMC Musculoskelet Disord. 2022 Apr 26;23(1):386.
17. Faschingbauer M, Sgroi M, Juchems M, Reichel H, Kappe T. Can the tibial slope be measured on lateral knee radiographs? Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2014 Dec;22(12):3163–7.
18. Dávila Castrodad IM, Recai TM, Abraham MM, Etcheson JI, Mohamed NS, Edalatpour A, et al. Rehabilitation protocols following total knee arthroplasty: a review of study designs and outcome measures. Ann Transl Med. 2019 Oct;7(Suppl 7): S255.
19. Shu L, Abe N, Li S, Sugita N. Importance of posterior tibial slope in joint kinematics with an anterior cruciate ligament-deficient knee. Bone Jt Res. 2022 Oct 11;11(10):739–50.
20. Plancher KD, Shanmugam JP, Brite JE, Briggs KK, Petterson SC. Relevance of the Tibial Slope on Functional Outcomes in ACL-Deficient and ACL Intact Fixed-Bearing Medial Unicompartmental Knee Arthroplasty. J Arthroplasty. 2021 Sep;36(9):3123–30.
21. Bellemans J, Robijns F, Duerinckx J, Banks S, Vandenneucker H. The influence of tibial slope on maximal flexion after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2005 Apr 1;13(3):193–6.
22. Bauer T, Biau D, Colmar M, Poux X, Hardy P, Lortat-Jacob A. Influence of posterior condylar offset on knee flexion after cruciate-sacrificing mobile-bearing total knee replacement: A prospective analysis of 410 consecutive cases. The Knee. 2010 Dec 1;17(6):375–80.
23. Patellofemoral instability after total knee arthroplasty (TKA) [Internet]. [cited 2024 Jun 12]. Available from: https://www.aofoundation.org/recon/clinical-library-and-tools/scientific-articles/10_1_preview_patellofemoral-instability-after-total-knee-arthroplasty-tka
24. Catani F, Fantozzi S, Ensini A, Leardini A, Moschella D, Giannini S. Influence of tibial component posterior slope on in vivo knee kinematics in fixed-bearing total knee arthroplasty. J Orthop Res Off Publ Orthop Res Soc. 2006 Apr;24(4):581–7.

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