ORIGINAL RESEARCH PAPER

Orthopedics

POST-OPERATIVE ASSESSMENT OF COMPONENT POSITIONING TKR

KEY WORDS:

Dr Raunak Satia Senior resident, Orthoprdics

Dr Abhishek Chabukswar Senior resident, Orthopedics

ABSTRACT

Background : Post-operative assessment of component positioning in total knee replacement (TKR) is a critical step in evaluating implant longevity, joint stability, and functional outcomes. The primary goal is to verify that the femoral, tibial, and patellar components are correctly aligned, balanced, and seated to restore natural biomechanics.Conventional Radiography: Weight-bearing anteroposterior (AP), lateral, and skyline (patella) views are the gold standard for initial assessments. They allow for assessing implant positioning, cement mantle integrity, and polyethylene wear. Computed tomography is increasingly utilized for a more precise three-dimensional (3D) evaluation particularly,for assessing rotational alignment. It removes the superimposition and projectional errors that can mask malposition on standard 2D X-rays.

INTRODUCTION :

Optimal treatment for Patients with "osteoarthritis " where conservative line of has not been successful require TKR which has a very good potential for recovery .[1, 2] Long-term survival rates with most of the implants is around 95%even after 10-year [5], around 20% of patients who undergo TKR report discontent with the results when assessed one year after the surgery.[6] One pivotal element influencing the achievement of favorable outcomes after TKR is the reinstatement of correct knee alignment. Misalignment of implants following primary TKA has been pinpointed as the leading cause of revision surgery in 7% of instances.[7] Improper positioning and alignment represent significant reasons for post-TKR pain. Typically, the evaluation of component positioning after TKR is carried out using radiographic methods. Noticeable misalignment, especially in terms of "varus-valgus and flexion-extension", may be detectable in radiographs. However, precise measurements can be challenging due to variations in leg rotation and magnification errors. Determining component rotation poses difficulties. Assessing outcomes after TKA has shifted toward functional measures, traditional X-rays and CT SCAN . Regular evaluation of component positioning using Computed tomography (CT) scans is gaining momentum in evaluation where it is possible to ascertain the postoperative placement of the components in sagittal, coronal, and rotational planes. [9, 10] Specifically, the alignment of components in the coronal plane has been predictable as a critical factor influencing the long-term achievement of mechanically aligned (MA) TKA implants.[10] Component Alignment in TKR Achieving proper knee alignment is a critical factor in ensuring successful outcomes following TKR.[34] Malalignment of the implant after the initial TKR has been identified as the leading cause of revisions, accounting for 7% of cases requiring revision.[35]Alignment Axes:The VA is a vertical line extending downward from the center of the pubic symphysis, as observed on a typical weight-bearing anteroposterior radiograph. This VA serves as a standard line for determining other axes.[11] The MA of the lower extremity is established by illustrating a line from the center of the femoral head to the center of the ankle joint. This line has an approximate inclination of 3° compared to the VA. Restoration of the HKA angle also refered as MA of lower limbs is one of the main aim of TKR .When full-length weight-bearing X-rays of the knee are unavailable, the Tibiofemoral Axis (TFA) can be determined from short anteroposterior knee radiographs. The acceptable alignment falls within the range of 7° to 9° of valgus. [12] CT scans can offer an alternative to routine assessment of component positioning.[13 14] Depending on the CT imaging protocol, it's possible to determine the postoperative sagittal, coronal, and rotational alignment of components.[15 16] Several methods have been described for these measurements. [13 17] Transverse 2D-CT slices are used to measure the angle between the surgical epicondylar axis and the posterior implant axis for rotational movement of FC . Alternatively, CT images are occasionally reconstructed in 3D, with the images aligned to standardized frames of reference, and rotational alignment is assessed based on these images.[18] Therefore, the present study was conducted to study the radiological evaluation of component positioning in TKR & and its correlation with pain postoperatively at 6 months.

AIM AND OBJECTIVES

Aim:

Radiological evaluation of component positioning in TKR & its correlation with pain postoperatively at 6 months.

Objectives:

1. To study pain assessment by VAS score.
2. To study component positioning under CT evaluation.
3. Correlation between pain and CT findings.

MATERIALS AND METHOD

The present Retrospective prospective observational cross-sectional study was conducted at a tertiary care centre after institutional ethical committee approval. A total of 30 TKR-operated patients were involved in the study. Any injury to the operated joint between the follow-up period and non-compliant subjects were excluded from the study.

Methodology

A written informed consent was taken from all the subjects before the initiation of the study. Patient history was collected by verbal communication. Clinical examination including routine radiological examination and a CT scan was done. Patients were followed up for CT scan post-operation and pain was assessed at 6 months by using the VAS score system pain evaluation at 6 months follow up using VAS score

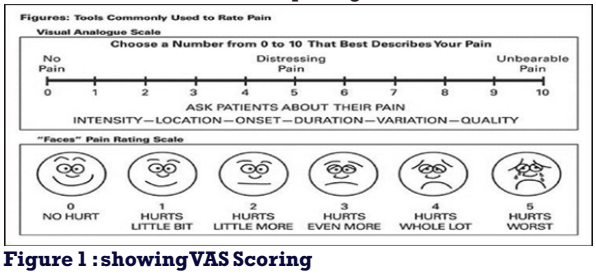


Figure 1 : showing VAS Scoring

Post-operative Evaluation

Patients were assessed by CT scan postoperatively and pain evaluation at 6 months follow up using VAS score

Table 1. CT assessment parameters [89, 90]

CORONAL ALIGNMENT OF FEMORAL AND TC	TARGET RANGE	INTERPRETATION
TIBIO FEMORAL ANGLE (TFA)	180	TFA =180 corresponds to neutral alignment TFA >180 corresponds to TFA in valgus TFA <180 corresponds to TFA in varus
ALPHA ANGLE	90	ALPHA =90 corresponds to the neutral placement ALPHA >90 corresponds to the valgus placement of the FC ALPHA <90 corresponds to varus placement of the FC
BETA ANGLE	90	BETA=90 corresponds to the neutral placement BETA >90 corresponds to the valgus placement of the FC BETA <90 corresponds to varus placement of the FC
SAGITTAL ALIGNMENT		
FLEXION OF FC (FF)	90	FF =90 corresponds to neutral placement FF >90 corresponds to a FC in the extension FF <90 corresponds to a FC in flexion
TIBIAL SLOPE (TS)	90	TS =90 corresponds to neutral placement TS >90 corresponds to the anterior tibial slope TS <90 corresponds to the posterior tibial slope
ROTATIONAL FC ANGLE (RFA)	0	
ROTATIONAL TC ANGLE (RTA)	0	
PATELLAR HEIGHT		
INSALL SALVATI INDEX	1.02	Ratio >1.2 indicates Patella Alta & <0.8 indicates Patella Baja

Statistical analysis

The data was assessed using SPSS V 23.0 software. Continuous variables were expressed in mean and standard deviation whereas, categorical variables were shown in frequency and percentage. t test was used to compare data between the studies. P<0.05 was considered as statistically significant.

RESULTS AND ANALYSIS

Age

Among the study participants, 20.00% (n=6) were aged 51-60 years, 56.67% (n=17) were aged 61-70 years, and 23.33% (n=7) were aged 71-80 years, making up a total of 30 individuals. The detailed distribution of age is mentioned in Figure 6.

Table 2 : Showing Age and Gender distribution

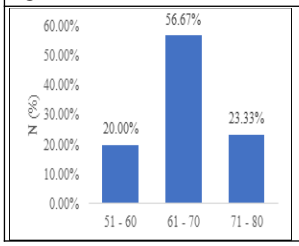
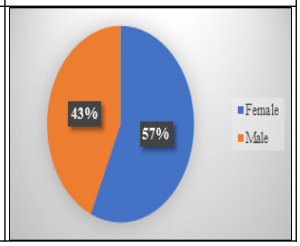
Age Distribution	Gender Distribution
	

Table 3 : Showing Comparison of Alpha with Beta Angle

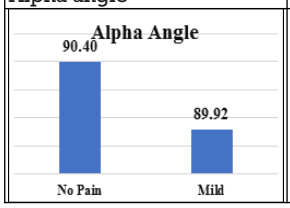
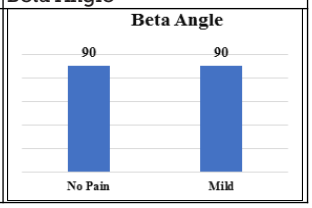
Alpha angle	Beta Angle
	

Table 4. Comparison of tibiofemoral angle according to pain intensities.

Pain Intensity	Tibio femoral angl		p-value
	Mean	SD	
Mild Pain	180.6	1.95	0.4361
No Pain	179.84	0.75	

Participants experiencing mild pain had a tibiofemoral angle with a mean of 180.6 and a standard deviation of 1.95, compared to those reporting no pain, whose mean angle was 179.84 with a standard deviation of 0.75 (P = 0.4361)..

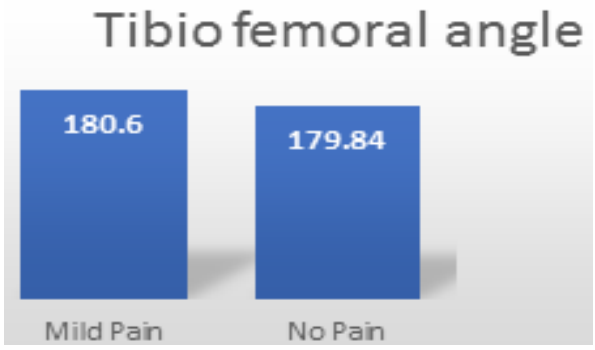


Table 5. comparison of flexion of femoral component according to pain intensity

Pain intensity	Flexion of Femoral		P-Value
	Mean	SD	
Mild Pain	90	0	0.05289
No Pain	90.16	0.37	

In the study, participants reporting mild pain exhibited a mean flexion angle of 90 for the FC, with negligible variation (SD = 0). Participants experiencing no pain showed a slightly higher mean flexion angle of 90.16, with a standard deviation of 0.37. P-value indicated no significant difference in flexion of FC when compared according to pain categories (P=0.05289).

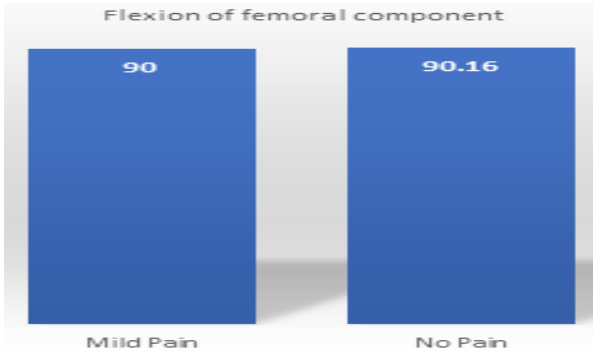


Table 6. Comparison of tibial slope according to pain categorie

Pain Intensity	TIBIAL SLOPE		P-Value
	Mean	SD	
Mild Pain	90	0	0.5743
No Pain	90.04	0.35	

In the study, participants with mild pain had a mean tibial slope of 90 (SD = 0). Those reporting no pain exhibited a slightly higher mean tibial slope of 90.04, with a standard deviation of 0.35. There was no significant difference in tibial slope when compared according pain categories (P=0.5743

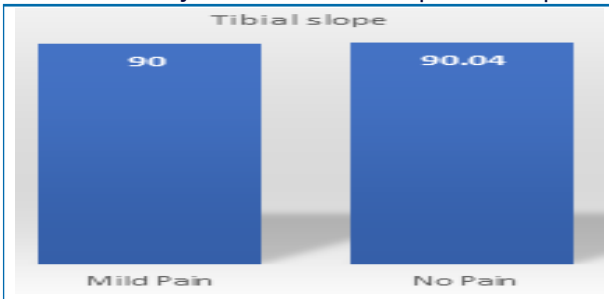


Table 7. comparison of rotational femoral component angle according to pain categories

Pain Intensity	Rotational Femoral Angle		P-Value
	Mean	SD	
Mild Pain	0.4	0.89	0.6548
No Pain	0.2	0.64	

In the study, participants experiencing mild pain had a mean rotational FC angle of 0.4 (SD = 0.89). In contrast, those without pain presented a mean angle of 0.2, with a standard deviation of 0.64. There was no substantial variation in rotational FC angle when compared according pain categories (P=0.6548).

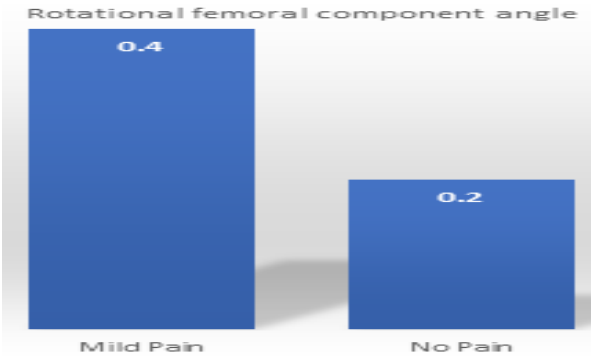


Table 8. Comparison of rotational tibial component angle according to pain categories

Pain Intensity	Rotational Tibial angle		P-Value
	Mean	SD	
Mild Pain		0	0.0829
No Pain	0.24	0.66	

Participants reporting mild pain had an average rotational TC angle of 0 (SD = 0), while those without pain showed a mean angle of 0.24 (SD = 0.66). The difference in angles between the two groups were P-value of 0.0829..

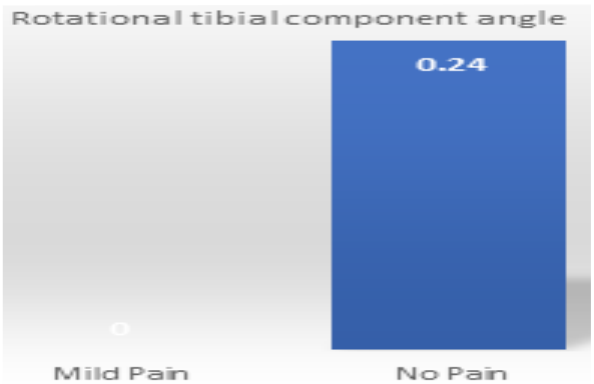
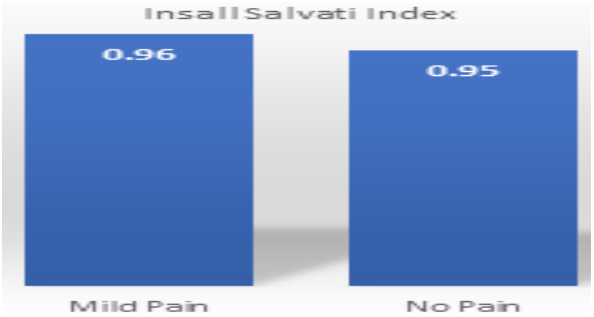


Table 9. Comparison of Insall Salvati index according to pain categories

Pain Intensity	INSALL SALVATI INDEX		P-Value
	Mean	SD	
Mild Pain	0.96	0.15	0.8863
No Pain	0.95	0.22	

Participants experiencing mild pain showed an average Insall Salvati index of 0.96 (SD = 0.15), whereas those without pain had a mean index of 0.95 (SD = 0.22). The difference in indices between the two groups was not statistically significant (P = 0.8863).



DISCUSSION

The present study aimed to evaluate the post-operative positioning of components in TKR and its correlation with pain experienced by patients at 6 months post-surgery. The demographic analysis revealed a predominant age group of 61-70 years, representing 56.67% of the participants, followed by 23.33% aged 71-80 years and 20% aged 51-60 years. This age distribution aligns with the general prevalence of knee OA, which is more common in older adults. Gender distribution showed a higher prevalence of females (56.67%) compared to males (43.33%), which is consistent with the epidemiology of knee OA being more common in females.

Knee instability with limitation in activity associated with pain lasting for more than six months was experienced by 32 % of patients who had undergone tkr as shown in literature search .[19] TKR involves the femoral and TCs within the knee, a hinge joint, which articulate with each other and the patellar and femoral surfaces within the patellofemoral joint. The interaction of FC with the polyethylene TC, tibial base plate, and polyethylene surface was the reason for flexion, extension, and some lateral/medial motion.[20] Post-TKR pain can be caused by changes in kinematics, altered ligament tensions, and increased retro patellar pressure, often resulting in anterior knee pain.[21-23] Poor positioning of the components affects the knee's kinematics, raising the risk of instability and polyethylene wear.[24 25] In vitro studies also show that component positioning influences ligament tension.[99, 100]Clinical studies have observed that internal rotation of the femoral implant component may contribute to patellofemoral pain syndrome [28 29]. Internal rotation increases stress leading to anterior knee pain, whereas external rotation of the trochlear groove and femoral component reduces retropatellar tension, thereby alleviating pain. [30]Fottner et al. conducted a study using computer simulations, which indicated that malpositioning of the tibial baseplate component primarily affects ligament tension (posterior cruciate and collateral ligaments). This alteration influences knee joint kinematics and contact forces between the tibia and femur, resulting in poorer clinical outcomes such as pain, higher rates of early loosening, instability, and reduced range of motion. Significant changes in kinematics were particularly noted in tibiofemoral rotation, with medial and lateral translation affecting tibiofemoral rollback, where medialization had the most significant impact. Similarly, Nicoll et al. demonstrated in their study that internal rotation errors of the tibial implant correlate with medial and anterior knee pain, particularly affecting the central part of the tibial tubercle or talus In our study, the tibio-femoral angle did not show a significant correlation with pain intensity. Participants with mild pain had a mean angle of 180.6° (SD = 1.95), while those with no pain had a mean angle of 179.84° (SD = 0.75) with a p-value of 0.4361. This suggests that slight variations in the tibio-femoral angle post-operatively do not significantly impact the pain experienced by patients. The alpha angle & the beta angle also do not show significance. Moreover, the mean flexion angle of the FC was 90° in participants with mild pain and 90.16° (SD = 0.37) in those without pain. Although the difference approached significance (p = 0.05289), it did not reach the threshold for statistical significance. This indicates

that while precise alignment is critical, minor deviations within this range do not necessarily correlate with increased pain.Furthermore, the tibial slope showed no significant difference between the two pain categories, with a mean of 90° (SD = 0) in the mild pain group and 90.04° (SD = 0.35) in the no pain group (p = 0.5743). This suggests that the tibial slope, within the evaluated range, is not a major determinant of post-operative pain. The rotational FC angle was slightly higher in the mild pain group (mean = 0.4°, SD = 0.89) compared to the no pain group (mean = 0.2°, SD = 0.64), but this difference was not statistically significant (p = 0.6548). This indicates that rotational alignment within these margins does not significantly influence post-operative pain levels. Participants with mild pain had a mean rotational TC angle of 0° (SD = 0), whereas those without pain had a mean angle of 0.24° (SD = 0.66), with a p-value of 0.0829. The insall- salvati index was similar between the two groups, with a mean of 0.96 (SD= 0.15) for mild pain & 0.95 (SD= 0.22) for no pain (P=0.8863). This indicates that the position of the patella, as measured by the insall salvati index, does not significantly correlate with pain outcomes post TKR Our study highlights that there is lack of a significant correlation between these parameters and VAS score suggests that component positioning alone may not be the sole determinant of postoperative pain. While precise component positioning is essential, it is equally important to consider other peri operative & post-operative factors that could influence patient outcome.We acknowledge certain limitations including: The study was conducted on a relatively small sample size of 30 participants. This limited sample size may reduce the statistical power of the study and affect the generalizability of the results to a broader population. The follow-up period for assessing post-operative pain and component positioning was limited to 6 months. A longer follow-up period would provide a more wide-ranging understanding of the long-term consequences and probable problems allied with TKR. This study was conducted at a single medical center, which may introduce center-specific biases related to surgical techniques, post-operative care, and patient demographics. Multi-center studies are needed to validate the findings across different settings and populations. The study did not include preoperative baseline data on pain levels and component positioning, which could provide valuable insights into the extent of improvement and the effectiveness of the surgical intervention.The study focused on a specific set of radiological parameters (Tibio-femoral angle, alpha angle, beta angle,flexion of FC, tibial slope, rotational FC angle, rotational TC angle, and Insall-Salvati Index). Other features such as ligament balance, soft tissue condition, and overall limb alignment were not evaluated and may also influence post-operative outcomes.While the study used the VAS for pain assessment, additional patient-reported outcome measures such as the Knee Society Score or the Western Ontario and McMaster Universities OA Index could provide a more comprehensive assessment of patient satisfaction and functional outcomes.
The study did not account for probable confounding factors such as patient comorbidities, variations in surgical method, and differences in post-operative restoration protocols, which could influence pain and component positioning outcomes.The study utilized CT scans for radiological evaluation, which, while accurate, may not capture dynamic factors affecting component positioning during functional activities. Future studies could incorporate advanced imaging techniques and biomechanical assessments to provide a more detailed analysis.

CONCLUSION

This study aimed to discover the correlation between component positioning in TKR as assessed by CT imaging & pain levels at 6 months post operatively, using the VAS score. The results indicated no significant difference in tibiofemoral angle, alpha angle, beta angle, flexion of femoral component, tibial slope, rotation of tibial & femoral component, insall salvati index across different VAS pain score groups suggesting that optimal component positioning alone may not be a determinant of postoperative pain outcome. Despite the importance of precise component positioning for the technical success of TKR, other factors such as surgical technique, rehabilitation protocols also play a crucial roles in post operative recovery & pain management.. These findings underscore the importance of multifaceted approach to post operative care, addressing both surgical & no- surgical factors to optimize patient outcomes in TKR.

REFERENCES :

1. Davies PS, Graham SM, Maqungo S, Harrison WJ. Total joint replacement in sub-Saharan Africa: a systematic review. Tropical Doctor. 2019 Apr;49(2):120-8.
2. Adie S, Harris I, Chuan A, Lewis P, Naylor JM. Selecting and optimizing patients for total knee arthroplasty. Medical Journal of Australia. 2019 Feb;210(3):135-41.
3. Naziri Q, Mixa PJ, Murray DP, Abraham R, Zikria BA, Sastry A, Patel PD. Robotic-Assisted and Computer-Navigated Unicompartmental Knee Arthroplasties: A Systematic Review. Surgical technology is international. 2018 Jun 1;32:271-8.
4. Nham FH, Patel I, Zalikha AK, El-Othmani MM. Epidemiology of primary and revision total knee arthroplasty: analysis of demographics, comorbidities, and outcomes from the national inpatient sample. Arthroplasty. 2023 Dec;5(1):1-8.
5. Steiger RN, Miller LN, Davidson DC, Ryan P, Graves SE. Joint registry approach foridentification of outlier prostheses. Acta orthopaedica. 2013 Aug 1;84(4):348-52.
6. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not?. Clinical Orthopaedics and Related Research®. 2010 Jan;468:57-63.
7. Kattimani R. Component alignment in total knee replacement. Orthop Rheumatol Open Access J. 2018;911:3-6.
8. Medical Advisory Secretariat. Total knee replacement: an evidence-based analysis. Ont Health Technol Assess Ser. 2005;5(9):1-51.
9. Hirschmann MT, Konala P, Amsler F, Iranpour F, Friederich NF, Cobb JP. The position and orientation of total knee replacement components: a comparison of conventional radiographs, transverse 2D-CT slices and 3D-CT reconstruction. The Journal of Bone & Joint Surgery British Volume. 2011 May 1;93(5):629-33.
10. Thakrar RR, Oussedik S. Assessing the Quality of Knee Component Position Following Kinematically Aligned Total Knee Arthroplasty. Personalized Hip and Knee Joint Replacement. 2020:329-41.
11 Schroer WC, Berend KR, Lombardi AV, Barnes CL, Bolognesi MP, Berend ME, Ritter MA, Nunley RM. Why are total knees failing today? Etiology of total knee revision in 2010 and 2011. The Journal of arthroplasty. 2013 Sep 1;28(8):116-9.
12. Fang DM, Ritter MA, Davis KE. Coronal alignment in total knee arthroplasty: just how important is it?. The Journal of arthroplasty. 2009 Sep 1;24(6):39-43.
13. Berger RA, RUBASH HE, SEEL MJ, THOMPSON WH, CROSSETT LS. Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis. Clinical Orthopaedics and RelatedResearch®. 1993 Jan 1;286:40-7.
14 Longstaff LM, Sloan K, Stamp N, Scaddan M, Beaver R. Good alignment after total knee arthroplasty leads to faster rehabilitation and better function. The Journal of arthroplasty. 2009 Jun 1;24(4):570-8.
15. Suter T, Zanetti M, Schmid M, Romero J. Reproducibility of measurement of femoral component rotation after total knee arthroplasty using computer tomography. The Journal of arthroplasty. 2006 Aug 1;21(5):744-8.
16. Victor J. Rotational alignment of the distal femur: a literature review. Orthopaedics & traumatology: surgery & research. 2009 Sep 1;95(5):365-72.
17. Nicoll D, Rowley DI. Internal rotational error of the tibial component is a major cause of pain after total knee replacement. The Journal of Bone & Joint Surgery British Volume. 2010 Sep 1;92(9):1238-44.
18. Hirschmann MT, Iranpour F, Konala P, Kerner A, Rasch H, Cobb JP, Friederich NF. A novel standardized algorithm for evaluating patients with painful total knee arthroplasty using combined single photon emission tomography and conventional computerized tomography. Knee Surgery, Sports Traumatology, Arthroscopy. 2010 Jul;18:939-44
19. Fleeton G, Harmer AR, Nairn L, et al. Self-reported knee instability before and after total knee replacement surgery. Arthritis Care Res (Hoboken) 2016;68:463–471.
20. Petersen W, Rembitzki IV, Brüggemann G-P, et al. Anterior knee pain after total knee arthroplasty: a narrative review. Int Orthop 2014;38:319–328.
21. Lützner J, Kirschner S, Günther KP, Harman MK. Patients with no functional improvement after total knee arthroplasty show different kinematics. Int Orthop 2012;36:1841–1847.
22. van Kempen RW, Schimmel JJ, van Hellemondt GG, Vandenneucker H, Wymenga AB. Reason for revision TKA predicts clinical outcome: prospective evaluation of 150 consecutive patients with 2-years followup. Clin Orthop Relat Res 2013;471:2296–2302.
23. Zihlmann MS, Stacoff A, Romero J, Quervain IK, Stüssi E. Biomechanical background and clinical observations of rotational malalignment in TKA: literature review and consequences. Clin Biomech (Bristol, Avon) 2005;20:661–668.
24. Howell SM, Hodapp EE, Vernace JV, Hull ML, Meade TD. Are undesirable contact kinematics minimized after kinematically aligned total knee arthroplasty? Anintersurgeon analysis of consecutive patients. Knee Surg Sports Traumatol Arthrosc 2013;21:2281–2287.
25. Kuriyama S, Ishikawa M, Furu M, Ito H, Matsuda S. Malrotated tibial component increases medial collateral ligament tension in total knee arthroplasty. J Orthop Res 2014;32:1658–1666.
26 Thompson JA, Hast MW, Granger JF, Piazza SJ, Siston RA. Biomechanical effects

of total knee arthroplasty component malrotation: a computational simulation. J Orthop Res 2011;29:969–975.
27. Murakami AM, Hash TW, Hepinstall MS, Lyman S, Nestor BJ, Potter HG. MRI evaluation of rotational alignment and synovitis in patients with pain after totaknee replacement. J Bone Joint Surg Br 2012;94:1209–1215.
28. Murakami AM, Hash TW, Hepinstall MS, Lyman S, Nestor BJ, Potter HG. MRI evaluation of rotational alignment and synovitis in patients with pain after totaknee replacement. J Bone Joint Surg Br 2012;94:1209–1215.
29. Barrack RL, Schrader T, Bertot AJ, Wolfe MW, Myers L. Component rotation and anterior knee pain after total knee arthroplasty. Clin Orthop Relat Res 2001;392:46–55.
30. Woiczinski M, Kistler M, Schröder C, et al. TKA design-integrated trochlea groove rotation reduces patellofemoral pressure. Knee Surg Sports Traumatol Arthrosc 2019;27:1680–1692.