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The Viability and Success of Noncemented Kinematic Total Knee Arthroplasty

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ABSTRACT

Background: The prevalence of noncemented total knee arthroplasty (TKA) is increasing as personalized knee alignment strategies deviate from implanting components on a strict mechanical axis. This retrospective study evaluated the outcomes of 74 consecutive noncemented unrestricted kinematic TKA procedures.

Methods: This study included 74 consecutive noncemented kinematic TKAs performed by one surgeon at a tertiary academic medical center from 2021 to 2023. The technique used was unrestricted femur-first caliper kinematic TKA. The outcomes included revision, pain scores, and radiographic measurements.

Results: Of the 74 procedures performed, there were no revisions or readmissions for problems related to TKA. The mean follow-up was 17.6 months, with 74% of patients being followed up for more than 1 year postoperatively. On the day of surgery, postoperative measurements showed that the average tibial mechanical, distal femoral, and anatomic tibiofemoral angles were 3.3°, 7.7°, and 5.8°, respectively. 5 knees were observed initially with signs of radiolucency, which all resolved by the most recent appointment. None of the knees was radiographically loose. Of the patients, 65%, 19%, and 16% reported no pain, minimal pain, and some pain, respectively, at the 6-week follow-up visit. This improved to 78%, 19%, and 3% at the most recent follow-up.

Conclusion: Combining kinematic alignment with noncemented fixation showed excellent clinical and radiographic outcomes with short-term survivorship. Although the use of both kinematic alignment and noncemented TKAs has been controversial, these early data suggest that noncemented kinematic TKA is safe and effective.

Noncemented total knee arthroplasty (TKA) has been shown to have excellent survivorship and functional outcomes, with one study listing 96.5% survivorship at 5 years.[1] When comparing modern noncemented with cemented mechanical TKAs, there has been no appreciable difference in gait, patient-reported outcomes, survivorship, revision rates, or knee function.[2-4] However, concerns persist over tibial fixation because of historic trends of fixation failures in this area.[5,6]

Kinematic alignment (KA) aims to reproduce the natural alignment of the knee, along with normal gait and ligament tension. Studies comparing standard mechanical TKAs with kinematic TKAs have shown that KA TKAs more closely resemble healthy controls and that patients who underwent KA TKA experienced less pain 6 weeks after surgery than those with mechanically aligned TKAs.[7,8]

Combining both techniques into noncemented kinematic TKA is controversial because of the concern that the shear stress caused by implanting a prosthesis at an oblique angle will cause the knee to fail. However, multiple studies have demonstrated excellent survivorship of cemented kinematic knees up to 10 years after implantation.[9] This is likely due to the more similar reproduction of native knee biomechanics and forces on the tibial implant. Furthermore, once the prosthesis is ingrown, the joint line obliquity theoretically presents less concern for loosening if there is no additional polyethylene wear. This is thought to be analogous to the successful results of noncemented hip fixation with stems in varus but poorer results with cemented stems.

The only other publication documenting the technique of combining noncemented fixation with kinematic angle implantation was presented in 2022 by Laforest et al.[10] This initial publication on 100 TKAs demonstrated that KA combined with a noncemented TKA implant allowed for adequate secondary fixation and good short-term functional outcomes. However, in the study, TKA alignment was restricted to a 3° deviation from mechanical axis of the hip-knee-ankle angle and/or 5 deviations of the distal femoral or proximal tibial angles. Additional clinical investigations are required to evaluate the safety and efficacy of this combination technique.

The purpose of this study was to evaluate the results of noncemented fixation in TKA with kinematically aligned implants.

Methods

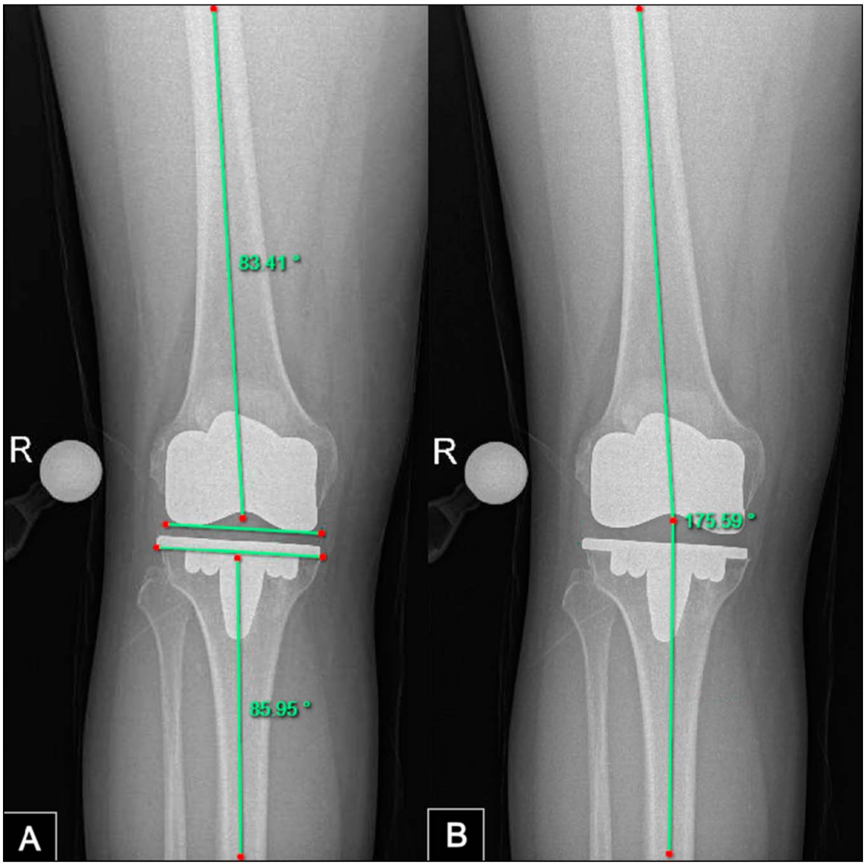
After obtaining Institutional Review Board approval, a retrospective chart review was conducted to examine patients who underwent kinematic TKA between May 2021 and April 2023. The current procedural terminology code 27447 was used to identify patients, with exclusion criteria consisting of patients with cemented knees and those undergoing revision procedures. Patient demographics, Charlson Comorbidity Index (CCI) scores, surgical data, and postoperative results were obtained. The CCI score considered the following comorbidities: AIDS, malignancy, cerebrovascular disease, chronic obstructive pulmonary disease, congestive heart failure, dementia, diabetes, hemiplegia, liver disease, myocardial infarction, peptic ulcer disease, peripheral vascular disease, chronic kidney disease, and rheumatic disease. Postoperative results included revisions, readmissions, and mortalities up to 1 year after surgery. Other data included reported extension, flexion, and total range of motion (ROM); reported pain level (defined as none, minimal, some, or high levels of pain); and TKA implant radiographic measurements. These angles included the tibial mechanical angle, distal femoral angle, and anatomic tibiofemoral angle on the day of surgery, at 6 weeks postoperatively, and at the most recent follow-up (Figure 1).

A single surgeon (NMB) performed kinematically aligned TKAs using manual instruments for each patient. Each arthroplasty began through medial parapatellar access with resection of the osteophytes, anterior cruciate ligament, and meniscus before completing a femur-first distal resection.[11] The posterior cruciate ligament was retained in all cases. Measurement of prosthetic implants followed the calipered technique detailed by Howell et al,[12] aiming to restore joint lines and limb alignments native to the patient. All implants used noncemented fixation.[3,4] All procedures used the cruciate-retaining ATTUNE knee prosthesis (DePuy, Warsaw IN, USA). Of the 74 operations performed, 36 used cobalt chrome rotating platform (RP) tibial baseplates and 38 used fixed-bearing (FB) titanium alloy tibial baseplates. 34 of the 36 operations with RP baseplates were performed before October 2023, after which time the surgeon switched to almost exclusively using FB baseplates. The 2 outlying operations that used RP baseplates in 2023 were performed in patients who already had RPs in their other knees. Thus, the same implant was used in these surgeries to match the successful implant they already had.

Statistical analysis was conducted using R Statistical Software (v4.2.2).[13] Statistical significance was determined for P values < 0.05. Descriptive statistics including percentages were determined for categorical patient variables. Means, standard deviations, and confidence intervals were calculated at a 95% confidence level for continuous variables. This study had four aims.

The first aim was to determine the short-term survivorship and radiographic outcomes (radiolucency,

Figure 1



Illustrations demonstrating measurement of each angle with one line parallel to the flat surface of the tibial or femoral implant and the other following the curvature of each bone's trajectory. **A,** Tibial mechanical angle (83.41°) and distal femoral angle (85.59°) measurements. (**B**) The anatomic tibiofemoral angle (175.59°) measurement in this example.

subsidence, or failure) of kinematic noncemented knee arthroplasty. Failure was assessed as any change in the prosthesis that required immediate surgical intervention or revision.

The second aim was to ascertain how patient characteristics, including sex, CCI score, age, race, ethnicity, and body mass index (BMI), influenced patient outcomes, including reported pain and extension, flexion, and total ROM. Univariate and multivariate linear regression models were used to estimate the effects of patient characteristics on ROM and pain scores while controlling for covariates. Multicollinearity in the models was evaluated using variance inflation factor scores.

The third aim was to determine the difference in outcomes and implant angles throughout the postoperative period. Regarding outcomes such as ROM measurements and pain scores, the Shapiro-Wilk test for normality was initially used, revealing a non-normal distribution of the data. Thus, a paired two-sample Wilcoxon test was implemented for comparisons. For the tibial mechanical angle, distal femoral angle, and anatomic tibiofemoral angle data sets, one-way analysis of variance was used to simultaneously compare mean values across the three time points. Post hoc statistical testing through Tukey comparison of means was applied but not reported, given the absence of statistical differences detected through analysis of variance.

The fourth aim was to evaluate any difference in performance between RP and FB tibial baseplates. An independent series of paired two-sample Wilcoxon tests was applied across all outcomes after Shapiro-Wilk testing revealed similarly non-normal distributions of data.

Results

Information on 74 consecutive noncemented kinematic TKAs was obtained from 66 patients in the study population—8 patients had undergone the procedure

Table 1. **Descriptive Statistics and Paired Two-Sample Wilcoxon Tests Comparing Range of Motion in Extension at 6 Weeks Postoperatively With Outcomes at the Most Recent Follow-Up**

Range of Motion—Extension: Variation			
Statistics	**6 Weeks**	**Most Recent F/U**	***P***
Minimum (°)	0	0	0.78
Mean (°)	0.51	0.45	
Maximum (°)	5	5	
Standard deviation (°)	1.50	1.41	
Confidence interval	0.17-0.86	0.13-0.77	

bilaterally. The average patient age was 64.5 years (range: 45-85 years), and 55.4% were female. The racial constitution of this cohort included 68.9% Caucasian/White, 17.6% Black/African American, 1.4% American Indian/Alaskan Native, and 12.2% classified as "other." Of our cohort, 90.5% were non-Hispanic or Latino/a and 5.4% were Hispanic or Latino/a. The average BMI of patients was 34.5 kg/m^2. 18 patients (24.3%) had CCI scores ≥ 5, indicating severe comorbidity risk. The most common comorbidities in our cohort were chronic obstructive pulmonary disease (28.4%) and diabetes (23.0%). Only 1 patient reported all-cause readmission within 1 year postoperatively (1.35%). The revision rate and all-cause mortality rate at 1 year postoperatively were both 0.00%.

At follow-up appointments of 6 weeks, 5 knees were found to have signs of radiolucency, of which two used FB baseplates and three RP baseplates. None were found to be radiographically loose. None of the patients had clinical or radiographic knee failures. The mean ROM at 6 weeks postoperatively was 120.1° (range: 85 to 135°), with a mean flexion of 120.4° and mean extension of 0.6°. 4 patients had ROM <105°. The patients' pain scores were reported in three categories: no pain (64.9%), minimal pain (18.9%), and some pain (16.2%). High levels of pain were not reported in any patient at 6 weeks.

For patients' most recent follow-up appointments, the average postoperative evaluation was at 17.6 months (range: 2-32 months). No knees showed any evidence of radiolucency, radiographic loosening, or failure. The mean ROM was 122.7° (range: 95-140°), with a mean flexion of 123.2° and mean extension of 0.45°. Only 1 patient continued having ROM <105°. Pain scores were distributed into no pain (78.4%), minimal pain (18.9%), and some pain (2.7%), with high pain not present in any patient. When evaluated statistically, no significant difference was present in any ROM outcome between 6 weeks postoperatively and at the most recent follow-up (Tables 1–3). Thus, it may be plausibly concluded that the strongest mechanical outcomes after noncemented kinematically aligned TKA appear by 6 weeks postoperatively and persist in the course following. In addition, pain scores at the most recent follow-up were significantly lower than at 6 weeks (P = 0.03, Table 4). This aligns with a sensible postoperative course and improvement with healing.

Univariate linear regression models for the measurements of ROM and pain scores revealed no statistically significant relationships between individual patient characteristics and outcomes at both 6-week and most recent follow-ups. When controlling for all variables in the multivariate regression models, a similar result was noted. Thus, it can be reasonably considered that patient

Table 2. **Descriptive Statistics and Paired Two-Sample Wilcoxon Tests Comparing Range of Motion in Flexion at 6 Weeks Postoperatively With Outcomes at the Most Recent Follow-Up**

Range of Motion—Flexion: Variation			
Statistics	**6 Weeks**	**Most Recent F/U**	***P***
Minimum (°)	90	95	0.08
Mean (°)	120.64	123.18	
Maximum (°)	135	140	
Standard deviation (°)	9.32	8.54	
Confidence interval	118.52-122.76	121.23-125.13	

Table 3. Descriptive Statistics and Paired Two-Sample Wilcoxon Tests Comparing Total Range of Motion at 6 Weeks Postoperatively With Outcomes at the Most Recent Follow-Up

Range of Motion—Total: Variation			
Statistics	6 Weeks	Most Recent F/U	*P*
Minimum (°)	85	95	0.10
Mean (°)	120.12	122.73	
Maximum (°)	135	140	
Standard deviation (°)	9.92	8.92	
Confidence interval	117.86-122.38	120.70-124.76	

characteristics including sex, age, CCI score, race, ethnicity, and BMI did not have a statistically significant association with worsened outcomes in ROM and pain in the postoperative course after noncemented kinematically aligned TKA (Tables 5–8).

Additional statistical analysis examined implant angle variation from radiographic imaging during the patients' TKAs, at 6 weeks postoperatively, and most recently. 3 metrics were used for this purpose, as presented in Figure 2. First, the tibial mechanical angle was measured as the angle from the tibial joint line to the tibial shaft axis, which varied by 2° to 3° from perpendicular.[14] This angle was then classified according to its degree of variation from 90°. Second, the femoral mechanical angle was measured as the angle from the femoral joint line to the femoral shaft axis, which normally varied by 8° to 9° valgus from perpendicular.[14] This angle was also classified based on the degree of variation from 90°. Finally, the anatomic tibiofemoral angle was measured as the angle between the femoral shaft axis extended distally and the tibial shaft axis, as a metric of the amount of anatomic malalignment in the knee.[14] This angle was classified by the degree of variation from 180°.

As detailed in Tables 9–11, there were no statistically significant differences between the variation in implant angles on the day of surgery, at 6 weeks postoperatively, and at the most recent follow-up. The average variation in the tibial mechanical angle remained approximately 3° from perpendicular, replicating the natural varus deviation expected in normal knee kinematics. Similarly, the average variation in the distal femoral angle was 7.7° from the mechanical axis throughout the postoperative course. Finally, the average tibiofemoral angle variation from 180° persisted from 5.8° on the day of surgery to 5.7° at 6 weeks postoperatively and back to 5.8° by the most recent follow-up. These radiographic measurements alongside ROM outcomes and pain scores were not markedly different between operations using RP tibial baseplates and FB tibial baseplates (Table 12).

Discussion

This study aimed to analyze a cohort of patients who underwent kinematically aligned TKA in a single institution setting. It sought to evaluate potential predictors of patient outcomes after the procedure alongside variations in implant positioning in the postoperative period. Toward the first and fourth aims, short-term clinical and radiographic performance of noncemented kinematically aligned TKAs was strong regardless of the

Table 4. Descriptive Statistics and Paired Two-Sample Wilcoxon Tests Comparing Pain Scores at 6 Weeks Postoperatively With Outcomes at the Most Recent Follow-Up. "No Pain" Was Ranked as 1, "Minimal Pain" as 2, "Some Pain" as 3, and "High Pain" as 4

Pain Score: Variation			
Statistics	6 Weeks	Most Recent F/U	*P*
Minimum (°)	1	1	0.03[a]
Mean (°)	1.51	1.24	
Maximum (°)	3	3	
Standard deviation (°)	0.76	0.49	
Confidence interval	1.34-1.68	1.13-1.35	

[a]Indicates statistical significance.

Table 5. Multivariate Linear Regression Model Calculating Odds Ratios and Confidence Intervals for Mean Range of Motion in Extension at 6 Weeks Postoperatively and the Most Recent Follow-Up for Each Variable Compared With Respective Dummy Variables (Sex: Female; Race: Caucasian/White; Ethnicity: Non-Hispanic or Latino/a)

Demographics Versus Range of Motion—Extension				
	6 Weeks Postoperatively		Most Recent F/U	
Variable	OR with 95% CI	P	OR with 95% CI	*P*
Sex-male	1.39 (0.69-2.81)	0.35	1.57 (0.82-3.02)	0.17
Age	1.03 (0.99-1.08)	0.10	1.03 (0.99-1.07)	0.12
CCI score	1.13 (0.97-1.31)	0.10	1.03 (0.89-1.19)	0.68
Race-Black/African American	1.59 (0.60-4.23)	0.35	1.59 (0.63-4.06)	0.32
Race-American Indian/Alaskan Native	7.83 (0.94-65.17)	0.06	0.64 (0.08-4.89)	0.67
Race-other	0.64 (0.22-1.86)	0.41	0.64 (0.23-1.78)	0.39
Ethnicity-Hispanic or Latino/a	0.58 (0.12-2.71)	0.47	0.66 (0.16-2.74)	0.56
BMI	1.05 (0.99-1.10)	0.09	1.00 (0.95-1.05)	0.99

tibial baseplate used. Toward the second aim, there is no evidence that any patient characteristics are associated with worse ROM and pain after kinematic knee arthroplasties. This supports previous findings that preprocedural factors such as age, sex, and BMI did not correlate with different reported outcomes after TKA.[15] Toward the third aim, implant angles remained in a consistent and reasonable range of presentation from immediately after surgery to the most recent follow-up. In addition, they highlighted the substantial natural variation in native knee anatomy. These angles were within the accepted parameters described in the literature with no evidence of prosthetic failure. These findings support the primary hypothesis that kinematic TKA offers a surgical alternative that is comparable with standard mechanical TKA.

These results align with those of the extensive literature on kinematic TKA as a substitute for mechanical TKA. Mechanical TKA carries intrinsic technical challenges that modern innovations, such as robotics, computer guidance, and new prosthetic designs, have yet to resolve.[16] For patients, there is notable long-term dissatisfaction after the procedure, with high rates of residual symptoms such as stiffness, pain, and tightness persisting for years postoperatively.[17] Thus, there is growing demand for options such as kinematic TKA to potentially offer improved outcomes. Evidence for such improvements has appeared in the short-term postoperative period, including faster recovery, improved reproduction of the original gait, and less reported pain.[2,7,8,18] However, some authors have disputed this, with Gao et al documenting nonsuperiority with

Table 6. Multivariate Linear Regression Model Calculating Odds Ratios and Confidence Intervals for Mean Range of Motion in Flexion at 6 Weeks Postoperatively and the Most Recent Follow-Up for Each Variable Compared With Respective Dummy Variables (Sex: Female; Race: Caucasian/White; Ethnicity: Non-Hispanic or Latino/a)

Demographics Versus Range of Motion—Flexion				
	6 Weeks Postoperatively		Most Recent F/U	
Variable	OR with 95% CI	P	OR with 95% CI	*P*
Sex-male	2.83 (0.04-223.10)	0.64	0.59 (0.01-32.23)	0.79
Age	0.80 (0.62-1.04)	0.10	0.90 (0.71-1.15)	0.40
CCI score	0.53 (0.21-1.33)	0.17	0.41 (∼0.00-92.83)	0.33
Race-Black/African American	0.08 (∼0.00-8.25)	0.23	0.02 (∼0.00-27.52)	0.42
Race-American Indian/Alaskan Native	∼0.00 (∼0.00-11,335)	0.19	∼0.00 (∼0.00-954.17)	0.56
Race-other	0.03 (∼0.00-0.91)	0.45	0.22 (0.001-48.50)	0.58
Ethnicity-Hispanic or Latino/a	0.01 (∼0.00-174)	0.36	0.03 (∼0.00-236.57)	0.44
BMI	0.75 (0.53-1.08)	0.12	0.72 (0.49-1.10)	0.30

Table 7. Multivariate Linear Regression Model Calculating Odds Ratios and Confidence Intervals for Mean Total Range of Motion at 6 Weeks Postoperatively and the Most Recent Follow-Up for Each Variable With Respective Dummy Variables (Sex: Female; Race: Caucasian/White; Ethnicity: Non-Hispanic or Latino/a)

Demographics Versus Range of Motion—Total				
	6 Weeks Postoperatively		Most Recent F/U	
Variable	OR with 95% CI	P	OR with 95% CI	*P*
Sex-male	3.79 (0.01-1021.44)	0.64	0.37 (0.01-24.37)	0.64
Age	0.74 (0.52-1.05)	0.09	0.87 (0.68-1.13)	0.29
CCI score	0.81 (0.24-2.74)	0.73	0.39 (0.06-9.35)	0.35
Race-Black/African American	0.02 (~0.00-11.46)	0.22	0.001 (~0.00-82.22)	0.07
Race-American Indian/Alaskan Native	~0.00 (~0.00-187011.1)	0.43	~0.00 (~0.00-256.70)	0.08
Race-other	0.14 (~0.00-1139.93)	0.67	0.35 (0.001-99.30)	0.71
Ethnicity-Hispanic or Latino/a	~0.00 (~0.00-473.28)	0.34	0.05 (~0.00-524.62)	0.52
BMI	0.72 (0.49-1.05)	0.09	0.78 (0.53-1.02)	0.06

symptoms, pain, and quality of life[19] and Young et al[20] noting that kinematic TKA produced similar but not necessarily better results and patient-reported outcomes. To resolve these discrepancies, multiple systematic reviews and meta-analyses specifically targeting randomized control trials have been conducted. Overall, these studies have concluded that the restoration of native patient mechanics through kinematic TKA offers better functional outcome scores, ROM on flexion, and longer walk distance than through mechanical TKA.[19,21-23]

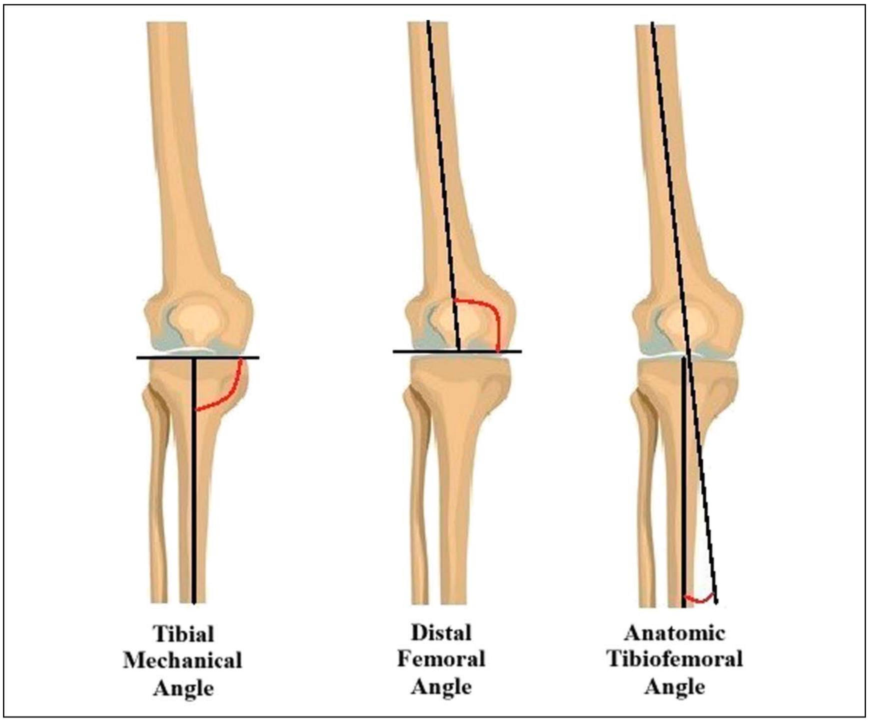
Regarding radiographic evaluation for kinematic TKA, there exists some concern regarding increased shear stress. Some studies have found that kinematic TKAs may result in a higher amount of postsurgical contact stress than mechanical TKAs.[2,24] Our results indicate no such problem. A recent study published by Stake et al[25] found that recreating native alignment decreases mechanical and shear stress on the bearing surfaces and the bone-implant interfaces. Kim et al[26] found that the increased stress at the patellofemoral compartment is because the trochlear design for most implants intends for mechanical implantation. Knee joint alignment had a high variance in adults.[27] This indicates that one possible reason for the success seen with KA TKA is that recreating the preoperative alignment of the knee more similarly reproduces a natural gait. This distributes equal pressure across the joint and thus decreases the overall stress placed on the knee.

The advantages of noncemented TKA are analogous to those of noncemented total hip arthroplasty. Studies

Table 8. Multivariate Linear Regression Model Comparing Patient Pain Scores at 6 Weeks Postoperatively and the Most Recent Follow-Up for Each Variable With Respective Dummy Variables (Sex: Female; Race: Caucasian/White; Ethnicity: Non-Hispanic or Latino/a)

Demographics Versus Pain Scores				
	6 Weeks Postoperatively		Most Recent F/U	
Variable	OR with 95% CI	P	OR with 95% CI	*P*
Sex-male	0.77 (0.22-2.63)	0.67	0.95 (0.75-1.19)	0.63
Age	1.02 (0.93-1.09)	0.83	0.99 (0.98-1.01)	0.26
CCI score	1.04 (0.80-1.36)	0.75	0.98 (0.93-1.03)	0.42
Race-Black/African American	2.46 (0.63-9.83)	0.19	1.25 (0.90-1.74)	0.17
Race-American Indian/Alaskan Native	~0.00 (~0.00-1.82e^{205})	0.99	0.79 (0.39-1.61)	0.52
Race-other	0.56 (0.05-4.02)	0.56	0.88 (0.62-1.26)	0.50
Ethnicity-Hispanic	4.12 (0.30-67.56)	0.28	1.03 (0.62-1.69)	0.92
BMI	1.01 (0.93-1.10)	0.77	0.98 (0.97-1.00)	0.17

Figure 2



Radiographs demonstrating implant angles measured based on the tibial shaft axis, femoral shaft axis, and respective joint lines for the 3 metrics.

have shown that noncemented hips have better or equal survivorship and less aseptic and radiographic loosening than their cemented counterparts.[3,28,29] Furthermore, there is no increased failure with noncemented hips implanted in varus.[30] Noncemented procedures have typically been performed in younger populations because high metabolic activity and good bone quality are the main indications for the noncemented procedure.[31] However, noncemented hip arthroplasty was successful in the elderly population as well.[32] In studies comparing full noncemented and full cemented fixation in primary TKA, there were no notable differences found in implant survivorship or radiolucent lines between the two methods at a mean follow-up of 7.1 years.[33] In studies comparing noncemented with cemented TKA with the same implant design, populations such as obese, morbidly obese, and younger active men showed greater success using noncemented knees over their cemented counterparts.[31] Just as noncemented THAs are a comparable and viable alternative to the standard method of cemented fixation, evidence exists for noncemented TKAs to show similar success.

This study evaluated the results of an unrestricted kinematic knee technique. There are multiple philosophies emerging regarding the optimal technique for personalizing TKA that take into consideration patient

Table 9. Descriptive Statistics and One-Way Analysis of Variance Comparing Variation of the Tibial Mechanical Angle From 90° Immediately Postoperatively With Outcomes at 6 Weeks and the Most Recent Appointment

Tibial Mechanical Angle: Variation				
Statistics	**Same Day**	**6 Weeks**	**Most Recent F/U**	***P***
Minimum (°)	0	0	0	0.89
Mean (°)	3.31	3.45	3.49	
Maximum (°)	11	11	11	
Standard deviation (°)	2.23	2.31	2.33	
Confidence interval	2.80-3.82	2.92-3.97	2.93–4.04	

Table 10. **Descriptive Statistics and One-Way Analysis of Variance Comparing Variation of the Distal Femoral Angle From 90° Immediately Postoperatively With Outcomes at 6 Weeks and the Most Recent Appointment**

Distal Femoral Angle: Variation				
Statistics	Same Day	6 Weeks	Most Recent F/U	*P*
Minimum (°)	1	3	3	0.98
Mean (°)	7.70	7.67	7.77	
Maximum (°)	13	13	13	
Standard deviation (°)	2.79	2.15	2.19	
Confidence interval	7.07-8.34	7.18-8.16	7.24-8.29	

outcomes and risk of failure. An unrestricted technique aims to restore prearthritic native anatomy regardless of the original alignment. Other surgeons restrict how far they will implant the knee outside of mechanical alignment in an attempt to decrease the risk of failure. There are emerging excellent long-term survivorship data on cemented unrestricted kinematic TKA.[34] However, these data are limited, and many surgeons think that one can restrict the alignment but maintain the coronal plane of alignment of the knee classification with similar outcomes but a theoretical lower risk of failure.[35]

Owing to the lack of mechanical TKAs compared with our completed kinematic TKAs, our study is limited in its ability to support kinematic TKAs as an alternative or superior technique to mechanical TKAs. Our study also consisted of a retrospective analysis of patient outcomes and implant positioning, limiting the statistical power of the conclusions available from our data. Our results are further limited by virtue of the TKAs being performed by a single surgeon using only 1 implant design within a single institution setting, introducing potential bias toward the nature of the procedures' results. In addition, there is a relatively small sample size and no comparison group, which further limits the generalizability. In choosing the tibial mechanical angle, distal femoral angle, and anatomic tibiofemoral angle to evaluate prosthetic success, we acknowledge that such radiographic measurements may not correlate with patient outcomes after kinematic TKA.[36] However, this relationship is yet to be fully elucidated, such that these angles continue to be the standard of practice implemented in our institution. Finally, our study is limited in some respects by not examining radiographic angles beyond 6 weeks postoperatively. The extent of this limitation was mitigated by following up on each patient regarding their procedure until their most recent presentation. The mean follow-up time from the surgical date was 17.6 months across all patients, with no failure observed throughout that time in any TKA completed. It was considered that if the prosthetic had not failed within three months, ingrowth had likely occurred. Despite that, longer follow-up is needed to fully validate this technique given the possibility of increased polyethylene wear. However, this has not been demonstrated in previous studies evaluating longer term outcomes of nonmechanical alignment.

Future studies should continue to explore kinematic TKA as a surgical technique compared with mechanical TKA. Given the preponderance of randomized controlled trials deployed to analyze this comparison,[8,37,38] study design should include a strong evaluation of both kinematic and mechanical approaches. In addition,

Table 11. **Descriptive Statistics and One-Way Analysis of Variance Comparing Variation of the Anatomic Tibiofemoral Angle From 180° Immediately Postoperatively With Outcomes at 6 Weeks and the Most Recent Appointment**

Anatomic Tibiofemoral Angle: Variation				
Statistics	Same Day	6 Weeks	Most Recent F/U	*P*
Minimum (°)	0	0	0	0.98
Mean (°)	5.83	5.73	5.82	
Maximum (°)	16	14	14	
Standard deviation (°)	3.31	2.92	2.96	
Confidence interval	5.08-6.59	5.07-6.40	5.12-6.53	

Table 12. Comparative Statistics Investigating Outcomes Between Knees With Rotating Platform Baseplates and Fixed-Bearing Baseplates Using Paired Two-Sample Wilcoxon Tests

Rotating Platform Versus Fixed-Bearing Baseplates for Outcomes			
Outcomes	**Mean: Rotating Platform**	**Mean: Fixed Bearing**	***P***
ROM extension-6 weeks	0.64°	0.40°	0.43
ROM extension-most recent F/U	0.40°	0.50°	0.67
ROM flexion-6 weeks	120.69°	120.58°	0.81
ROM flexion-most recent F/U	122.36°	123.95°	0.47
ROM total-6 weeks	120.06°	120.18°	0.80
ROM total-most recent F/U	121.86°	123.55°	0.53
Pain score-6 weeks	1.50	1.53	0.99
Pain score-most recent F/U	1.19	1.29	0.34
Tibial mechanical angle-6 weeks	3.03°	3.58°	0.11
Tibial mechanical angle-most recent F/U	7.47°	7.92°	0.35
Distal femoral angle-6 weeks	6.19°	5.49°	0.66
Distal femoral angle-most recent F/U	3.39°	3.50°	0.68
Anatomic tibiofemoral angle-6 weeks	7.64°	7.71°	0.88
Anatomic tibiofemoral angle-most recent F/U	5.81°	5.66°	0.87

while different meta-analyses have broadened the sample sizes for appraising kinematic TKA against mechanical TKA,[19,21-23] there remains interest in larger scale randomized control studies to better capture the outcomes of the two techniques across multiple patient populations. These studies should include the application of noncemented TKAs with kinematic techniques as described thus far.

Conclusion

Despite the controversy regarding the use of KA with noncemented fixation, the results of this study are promising for the future application of this method. Kinematic TKA offers a safe and reliable treatment modality with the use of noncemented knee technology. Restoring joint alignment native to the patient is a supported surgical approach, with no evidence of patient characteristics affecting its success. These data, albeit limited, showed no failures and minimal radiologic abnormalities with the technique.

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