Original Article
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No Difference in Clinical Outcomes and Survivorship for Robotic, Navigational, and Conventional Primary Total Knee Arthroplasty with a Minimum Follow-up of 10 Years

Young Min Lee, MD, Gun Woo Kim, MD, Chan Young Lee, MD, Eun-Kyoo Song, MD, Jong-Keun Seon, MD

Center for Joint Disease, Chonnam National University Hwasun Hospital, Chonnam National University Medical School, Hwasun, Korea

Background: Computer-assisted surgery, including robotic and navigational total knee arthroplasty (TKA), has been proposed as a technique used to improve alignment of implants. The purpose of this study was to compare the clinical and radiological outcomes during a minimum follow-up period of 10 years among robotic, navigational, and conventional TKA.

Methods: A total of 855 knees (robotic group, 194; conventional group, 270; and navigational group, 391) were available for physical and radiological examinations over a mean follow-up period of 10 years. The survival rate was analyzed using the Kaplan-Meier method based on the survival endpoint. The Hospital for Special Surgery score, Western Ontario and McMaster Universities Osteoarthritis Index, Knee Society Score, and range of motion were used for clinical evaluation. The hip-knee-ankle (HKA) axis angle, the coronal inclination of femoral and tibial components, and the presence of radiolucent lines were also assessed at the final follow-up.

Results: All clinical assessments at the final follow-up revealed improvements in the three groups without any significant difference among the groups ($p > 0.05$). The cumulative 10-year survival rate was 97.4% in the robotic group, 96.6% in the conventional group, and 98.2% in the navigational group, with no significant difference ($p = 0.447$). The rates of complication-associated surgery were not significantly different among the groups ($p = 0.907$). Only the proportion of outliers in the HKA axis angle showed a significant difference ($p = 0.001$), but other radiological outcomes were not significantly different among the three groups.

Conclusions: Our study demonstrated satisfactory survival rates for robotic, navigational, and conventional TKAs and similar clinical outcomes during the long-term follow-up. Larger studies with continuous serial data are needed to confirm these findings.

Keywords: *Arthroplasty, Knee, Robotic surgery, Navigation, Conventional*

Total knee arthroplasty (TKA) has been established over the past decades as a reliable and effective surgical procedure for reducing pain and restoring physical function in patients with severe osteoarthritis. Several studies have demonstrated that optimal positioning and neutral alignment may improve the functionality of the knee and implant survival during a long-term follow-up.[1,2] However, greater than 3° malalignment is estimated to occur in up to 30% of patients who undergo conventional TKA.[3] Hence, much effort has been made to improve the implant positioning and lower limb alignment through computer-assisted orthopedic surgery including robotic and navigational TKA.[4,5] Few studies have investigated whether

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Correspondence to: Eun-Kyoo Song, MD
Center for Joint Disease, Chonnam National University Hwasun Hospital, Chonnam National University Medical School, 322 Seoyang-ro, Hwasun 58128, Korea
Tel: +82-61-379-7677, Fax: +82-61-379-7676
E-mail: eksong@jnu.ac.kr
Co-Correspondence to: Jong-Keun Seon, MD
Center for Joint Disease, Chonnam National University Hwasun Hospital, Chonnam National University Medical School, 322 Seoyang-ro, Hwasun 58128, Korea
Tel: +82-61-379-7677, Fax: +82-61-379-7676
E-mail: seonbell@jnu.ac.kr

there are differences in long-term functional outcomes and survivorship between computer-assisted TKA and conventional TKA.[6,7] However, because most of the aforementioned studies involved a small sample size, evaluated previous generation implants, and produced conflicting results, it remains unclear whether the long-term functional outcome or survivorship differs between computer-assisted TKA, including robotic and navigational, and conventional TKA. Moreover, no study has compared the outcomes of a long-term follow-up among the three groups. Therefore, due to the lack of research, comparative long-term effectiveness of conventional TKA, robotic TKA, and navigational TKA reamins controversial.

The purpose of this study was to compare radiological and clinical outcomes, survivorship, and complication rates among robotic, navigational, and conventional TKA for a minimum follow-up of 10 years. We hypothesized if computer-assisted TKA was more accurate than conventional TKA, significant differences would be shown clinically and radiologically.

METHODS

The study was approved by the Institutional Review Board of Chonnam National University Hwasun Hospital (No. CNUHH-2014-106) and a retrospective analysis was performed. Between January 2004 and December 2009, we identified patients (1) who underwent TKA because their mechanical axis was between 20° varus and 10° valgus and they had primary osteoarthritis of the knee and (2) who had a minimum follow-up of 10 years. The exclusion criteria were a previous open knee surgery, a neurological defect affecting the lower extremity, or severe instability that could not be treated by TKA. We identified 1,164 patients (1,397 knees) for this study, including 313 patients (325 knees) who underwent robotic TKA using ROBODOC (Think Surgical, Fremont, CA, USA), 501 patients (652 knees) who underwent navigational TKA using Orthopilot, and 350 patients (420 knees) who underwent conventional TKA. Each operation was randomly selected and the type of implant (cruciate-retaining [CR] or posterior-stabilized [PS]) was randomly selected. Patellar resurfacing was not performed, only osteophytectomy was done. During the follow-up, 352 patients were lost to follow-up and 85 patients died. In addition, patients who underwent revision TKA or experienced other complications significantly affecting the clinical outcomes were assessed just before the revision surgery or before the complication occurred. Finally, this study included 188 patients (194 knees) who underwent robotic TKA using ROBODOC, 306 patients (391 knees) who underwent navigational TKA using Orthopilot, and 233 patients (270 knees) who underwent conventional TKA. The patients' basic demographics are shown in Table 1. For 88 of the 188 patients in the robotic group, 142 of the 306 patients in the navigational group, and 79 of the 233 patients in the conventional group who could not visit the hospital for follow-up, the authors assessed current conditions using a questionnaire (Fig. 1).

Table 1. Comparison of Preoperative Demographic Data and Clinical Outcomes

Parameter	Robotic group (n = 194)	Conventional group (n = 270)	Navigational group (n = 391)	*p*-value
Mean age (yr)	71.8 ± 8.2	71.0 ± 7.0	71.6 ± 8.1	0.603
Sex (male : female)	18 : 176	20 : 250	26 : 365	0.523
Mean follow-up duration (yr)	11.9 ± 1.5	11.8 ± 1.5	12.0 ± 1.4	0.358
Range of motion (°)	125.1 ± 13.6	123.2 ± 17.3	123.1 ± 14.7	0.210
Implant type (CR : PS)	8 : 186	12 : 258	21 : 370	0.760
HSS score	63.1 ± 12.8	61.4 ± 11.1	61.3 ± 12.0	0.243
KSS pain score	22.4 ± 7.5	22.8 ± 10.4	23.4 ± 9.8	0.399
KSS function score	50.5 ± 15.9	48.1 ± 17.1	48.1 ± 14.7	0.217
WOMAC score	66.5 ± 13.9	66.2 ± 15.9	66.7 ± 14.1	0.754

Values are presented as mean ± standard deviation.
CR: cruciate-retaining, PS: posterior-stabilized, HSS: Hospital for Special Surgery, KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

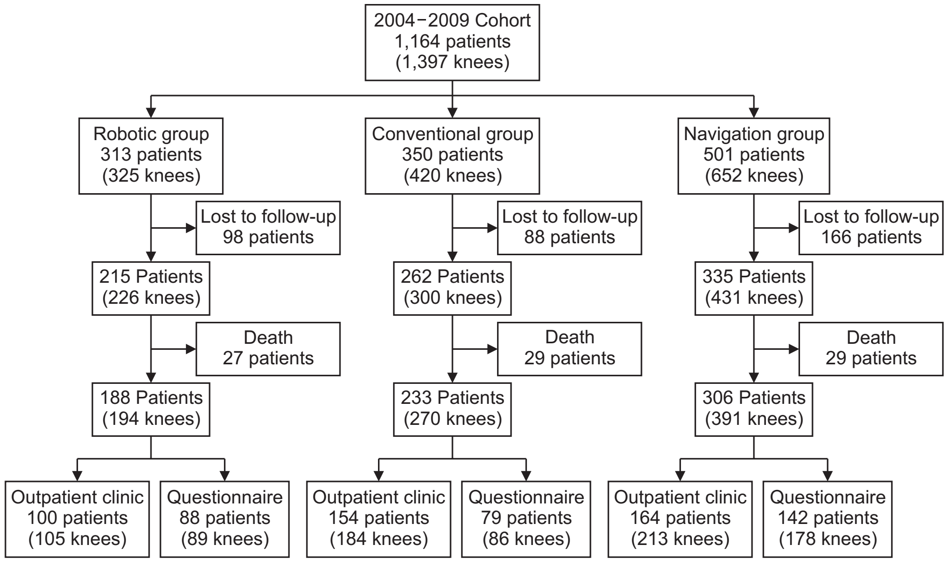

Fig. 1. Patient selection flowchart.

Surgical Procedure: ROBODOC-Assisted TKA, Navigational TKA, and Conventional TKA

All knees were exposed with a standard midline incision through the medial parapatellar approach, and the patella was everted laterally. In the ROBODOC-assisted TKA, NexGen (Zimmer Inc., Warsaw, IN, USA) prostheses were used in all cases, and it involved a two-step process. The first step was to perform computed tomography-based preoperative planning using the ORTHODOC workstation (integrated surgical system) prior to the day of surgery. The second step was robotic surgery using ROBODOC Surgical assistant. Rigidly connected to the patient's leg during the surgery, the robot registered bony landmarks on both the femur and tibia using a probe. After the registration was accomplished successfully, bone resection was performed automatically by the ROBODOC as planned preoperatively using the ORTHODOC system. The distal femur and proximal tibia were resected perpendicular to the mechanical axis, with a 7° posterior slope to the mechanical axis of the tibia in the sagittal plane. Femoral rotational alignment was planned perpendicular to the transepicondylar axis and the tibial rotational axis was oriented parallel to the femur.[8)]

For navigation-assisted TKA, the Orthopilot Version 4.0 or 4.2 (Aesculap, Tuttlingen, Germany) imageless navigation system and E-motion prosthesis (B. Braun Aesculap) were used in all cases. Two 4.5-mm pins were used to attach navigation trackers to the femur and tibia. After navigation registration, a tibial cut was performed perpendicular to the tibial mechanical axis with a 0° posterior slope. Using real-time data from the navigator, extension and flexion gap was balanced by a modified gap balance technique. The distal femoral cut was performed perpendicular to the femoral mechanical axis. The size and rotation of the femoral component were determined with computer navigation. After confirming limb alignment on the navigator, implants were cemented onto the femoral and tibial surfaces.[9)]

Conventional TKA was performed following the operator's technique using manual instruments. Similar to the ROBODOC-assisted TKA, NexGen (Zimmer Inc.) prostheses were used in all cases. Using the tibia-first modified gap balance technique, bone resection was performed after exposure of the knee joint. Tibial preparation was performed using an extramedullary cutting guide with proximal tibial resection perpendicular to the mechanical axis with a 7° posterior slope. The tibial component was aligned to the line connecting the edge to the medial 1/3 of the tibial tuberosity and the posterior cruciate ligament insertion site. Distal femoral preparation was performed using an intramedullary rod guide with 5° of valgus, and femoral rotation was determined according to the balanced flexion gap. After the bone resection, ligament balancing including deep medial collateral ligament (MCL) release, posterior capsular release, and sub-periosteal superficial MCL release were performed as needed. When the ligament balancing was completed, femoral and tibial implants were placed using bone cement.

The intraoperative and postoperative pain and rehabilitation protocols were identical in the three groups. Immediately after surgery, all patients underwent standardized physical therapy beginning with full weight-bearing on the first postoperative day.

Clinical Evaluations

Clinical evaluations were conducted 3, 6, and 12 months after the surgery and annually thereafter. Data analyses were conducted by two observers who were not involved in the surgery (GWK and YML), collectively preoperatively and during the last follow-up. During the follow-up, the clinical status of all patients and the range of motion (ROM) were evaluated using a standard goniometer, the Hospital for Special Surgery (HSS) score, Knee Society Score (KSS, pain and function), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scoring system, and the presence of complications (polyethylene wear, infection, aseptic loosening, instability, patella problem, and periprosthetic fracture) was investigated. We also used the Kaplan-Meier survival analysis to estimate the overall survival of the femoral and tibial components, with revision for any reason as the endpoint. Additionally, the survival rates of components, with revision except in the case of infection as the endpoint, were also estimated.

Radiological Evaluations

Supine anteroposterior and lateral radiographs and standing anteroposterior hip-knee-ankle (HKA) radiographs were obtained preoperatively and at each follow-up. A separate observer who was unaware of the clinical outcomes (CYL) evaluated the HKA axis angle and the presence of radiolucent lines according to the recommendation of the KSS system for radiographic scoring.[10] Also, the coronal inclinations of femoral and tibial components (α, β) were measured using anteroposterior radiographs (Fig. 2). Because the recommended posterior slope of the tibial component is different for each implant, the sagittal inclination of femoral and tibial components were not measured. Outliers were defined when the measured angle exceeded ± 3° from the neutral alignment in each radiological measurements on a final follow-up radiograph. For the evaluation of HKA angles, the coronal inclination of components and radiolucent lines were assessed, and intraclass correlation coefficients were used to evaluate inter- and intraobserver reliability (ranges between 0.81 and 0.87).

The Picture Archiving and Communication Systems digital radiographic software (Infinitt Healthcare, Seoul, Korea) was used for all the measurements because it allows for magnification of images and provides measurement values with precision to two decimal places.

Statistical Analysis

Statistical analyses were performed using IBM SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). The means, standard deviations, and frequencies were analyzed. To compare the differences within the groups, analysis of variance was used. The chi-square test or Fisher's exact test was used for categorical variables.

The cumulative survival rate during the 10-year follow-up evaluation using the log rank test was compared among the three groups. Differences with $p < 0.05$ were considered statistically significant. Also, we used the Cox multiple regression model to calculate the risk ratio for patient demographics and surgical variables.

RESULTS

Age at the time of operation ($p = 0.603$) and sex ($p = 0.523$) were not significantly different among the three groups. All the three groups also had similar mean preoperative HKA axis angle, ROM, HSS score, KSS (pain and function subscales), and WOMAC score. In addition, the proportion of PS implants was 4.1% in the robotic group, 4.4% in the navigational group, and 5.3% in the conventional group, showing no significant difference ($p = 0.760$) (Table 1).

At the last follow-up (more than 10 years after operation), all functional outcomes (ROM, HSS, KSS, and WOMAC scores) were significantly improved compared with the preoperative status in all three groups. No significant differences were detected among the three groups based on the clinical outcomes at the final follow-up ($p > 0.05$) (Table 2).

The HKA axis angle of the knee was significantly

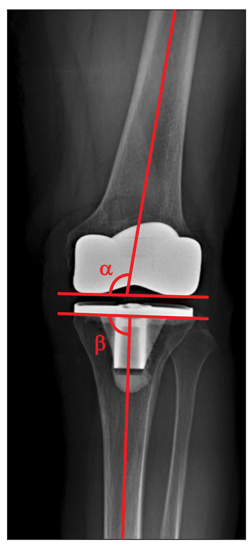

Fig. 2. Radiologic measurement of femoral and tibial implants. α: coronal inclination of femoral component, β: coronal inclination of tibial component.

Table 2. Clinical Outcomes at the Final Follow-up

Parameter	Robotic group (n = 194)	Conventional group (n = 270)	Navigational group (n = 391)	*p*-value
Range of motion (°)	130.2 ± 14.5	129.8 ± 15.1	129.9 ± 13.7	0.936
HSS score	86.8 ± 12.7	87.5 ± 13.0	86.8 ± 13.7	0.608
KSS pain score	44.4 ± 7.2	44.3 ± 7.7	43.4 ± 9.0	0.849
KSS function score	85.3 ± 7.7	86.5 ± 14.9	85.5 ± 13.7	0.540
WOMAC score	13.8 ± 11.4	14.7 ± 15.8	15.0 ± 12.6	0.619

Values are presented as mean ± standard deviation.
HSS: Hospital for Special Surgery, KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Table 3. Radiologic Outcomes with Outliers at Final Follow-up

Variable	Robotic group (n = 105)	Conventional group (n = 184)	Navigational group (n = 213)	*p*-value
HKA axis angle				
Preoperative (varus)	10.6 ± 5.1	10.1 ± 6.8	10.2 ± 6.6	0.824
Last follow-up (varus)	1.3 ± 1.4	1.6 ± 2.0	1.4 ± 1.8	0.365
Coronal inclination angle				
Femoral implant	95.5 ± 2.3	95.5 ± 2.6	95.3 ± 2.7	0.632
Tibial implant	89.6 ± 1.8	90.1 ± 1.9	89.8 ± 2.0	0.083
Outliers				
HKA axis angle	10 (9.5)	47 (25.7)	30 (14.1)	0.001
Coronal femoral inclination	20 (19)	39 (21.3)	58 (27.2)	0.192
Coronal tibial inclination	5 (4.8)	20 (10.9)	20 (9.4)	0.204

Values are presented as mean ± standard deviation or number (%).
Outliers: measured angle exceeding ± 3° from the neutral alignment, HKA: hip-knee-ankle.

improved in all three groups without any significant difference at the final follow-up evaluation of the radiological outcomes (robotic group, 1.3° ± 1.4°; navigational group, 1.6° ± 2.0°; conventional group, 1.4° ± 1.8°; $p = 0.365$). The proportion of outliers in the HKA axis angle showed a significant difference (robotic group, 10/105; conventional group, 47/183; navigational group, 30/213; $p = 0.001$). When comparing in pairs of two groups, both the robotic group and the navigational group showed a statistically significant difference compared to the conventional group (vs. robotic, $p = 0.001$, vs. navigational, $p = 0.004$), but there was no statistically significant difference between the robotic group and the navigation group ($p = 0.249$). Also, no significant differences were found in the proportion of outliers in the postoperative coronal inclination of femoral and tibial components among the three groups (tibial side, $p = 0.192$; femoral side, $p = 0.204$) (Table 3).

Radiolucent lines were observed on the tibial side in 7 knees (6.7%) and on the femoral side in 6 knees (5.7%) in the robotic group, on the tibial side in 12 knees (6.6%) and on the femoral side in 11 knees (6.0%) in the conventional group, and on the tibial side in 15 knees (7.0%) and on the femoral side in 13 knees (6.1%) in the navigational group, without a significant difference among the three groups (tibial side, $p = 0.980$; femoral side, $p = 0.990$) (Table 4).

In terms of complications, the rate of complication-associated surgery was 4.6% in the robotic group, 5.6% in the conventional group, and 5.1% in the navigational group without any significant difference ($p = 0.907$). There were 2 cases of infection in the robotic group, 3 cases of infection in the conventional group, and 5 cases of infec-

Table 4. Radiolucent Lines in Radiographs at Final Follow-up

Variable	Robotic group (n = 105)	Conventional group (n = 184)	Navigational group (n = 213)	*p*-value
Radiolucent line (overall)				
Tibial side	7 (6.7)	12 (6.6)	15 (7.0)	0.980
Coronal aspect				
Zone 1	6	9	10	
Zone 2	2	4	5	
Zone 3	1	1	0	
Zone 4	0	1	0	
Zone 5	0	0	2	
Zone 6	0	0	0	
Zone 7	2	1	2	
Sagittal aspect				
Zone 1	0	0	0	
Zone 2	0	0	0	
Zone 3	0	0	0	
Femoral side	6 (5.7)	11 (6.0)	13 (6.1)	0.990
Sagittal aspect				
Zone 1	4	6	8	
Zone 2	1	5	4	
Zone 3	0	0	1	
Zone 4	0	1	0	
Zone 5	0	0	2	
Zone 6	0	0	0	
Zone 7	1	0	3	

Values are presented as number (%).

tion in the navigational group, all of which required revision TKA. Aseptic loosening was found in 5 patients in the robotic group. In the conventional group, aseptic loosening was observed in 8 cases, and in the navigational group, aseptic loosening was observed in 8 cases. However, 2 patients with aseptic loosening in the navigational group refused to undergo implant revision.

A total of 30 revisions (3.5%) were performed during the follow-up, including 7 cases (3.6%) in the robotic group, 12 cases (4.4%) in the conventional group, and 11 cases (2.8%) in the navigational group, and there was no significant difference between groups ($p = 0.532$) (Table 5).

In the Kaplan-Meier survival analysis, revision of the tibial and/or femoral component was the endpoint. The cumulative survival rate, excluding revision cases due to infection, was 97.4% in the robotic group, 98.2% in the navigational group, and 96.6% in the conventional TKA group with reliable survival of 10 years postoperatively (Fig. 3). No significant difference was identified clearly among the three groups using the log-rank analysis ($p = 0.447$). Cox regression analyses were performed with adjustments for age, sex, body mass index, implant type (CR or PS), and side (left or right). The Cox regression analysis did not show any significant difference in the risk of revision among the three groups ($p > 0.05$) (Table 6).

Table 5. Complications until Last Follow-up

Parameter	Robotic group (n = 194)	Conventional group (n = 270)	Navigational group (n = 391)	*p*-value
Patients with complications	9 (4.6)	15 (5.6)	20 (5.1)	0.907
Patients with revision	7 (3.6)	12 (4.4)	11 (2.8)	0.532
Aseptic loosening	5	8	8	
Infection	2	3	5	
PE wear	0	1	2	
Patella problem	0	2	2	
Instability	1	1	1	
Periprosthetic fracture	1	0	2	

Values are presented as number (%).
PE: polyethylene.

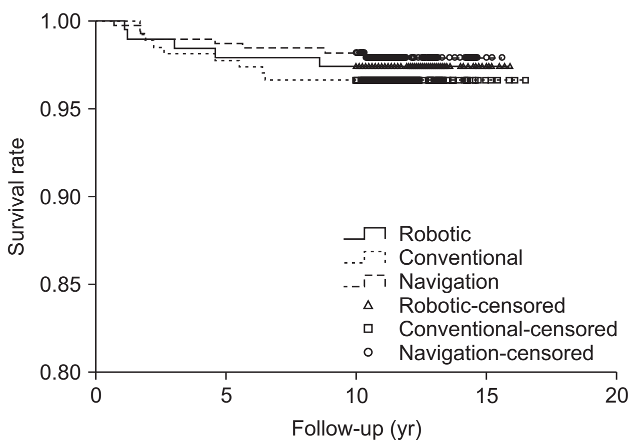

Fig. 3. Kaplan-Meier 10-year survival analysis excluding revision cases due to infection. $p = 0.447$.

DISCUSSION

The major finding of our study is that there was no difference in clinical or radiologic long-term outcomes except for the proportion of outliers in postoperative HKA axis angle among the robotic, navigational, and conventional TKA groups after a minimum follow-up of 10 years. Moreover, our study demonstrated satisfactory survival rates and similar complication rates for robotic, navigational, and conventional TKA.

In terms of clinical outcomes, our study revealed that there was no significant difference among the three groups regarding the ROM, HSS score, KSS pain and functional score, and WOMAC score during long-term follow-up. These results appear to be similar to those described in previously published studies on computer-assisted TKA after a long-term follow-up period of at least 10 years. Few studies have evaluated whether there are differences in long-term functional outcomes and survivorship among the types of computer-assisted TKA including robotic, navigational, and conventional TKA.[6,7] In a prospective study involving 100 knees, one study compared clinical outcomes following navigational TKA with those of conventional TKA during a mean follow-up of over 12 years. The authors observed no differences in the knee and functional scores.[11] Furthermore, in other studies that compared navigational and conventional TKA, no statistically significant differences, based on the most common clinical evaluations, were reported.[12,13] When comparing robotic TKA and conventional TKA, Jeon et al.[7] reported no differences in Knee Society Scores and the 36-item short form survey between ROBODOC-assisted TKA and conventional TKA during a 10-year mean follow-up period. Similarly, another study reported no significant difference between the two groups in terms of satisfactory improvement of ROM, knee score, and functional score after a mean follow-up period of 10 years. Compared to computer-assisted orthopedic surgery (CAOS), including robotic and navigational TKA, conventional TKA showed satisfactory clinical outcomes in our study.

Accurate TKA prosthesis positioning is widely considered as an important predictor of patient satisfaction and implant durability.[14,15] In addition, several studies reported that greater than 3° mechanical alignment after TKA and implant malpositioning are consequential factors that affect implant longevity.[16,17] Computer-assisted TKA, including robotic-assisted TKA and navigational TKA, was therefore introduced to improve implantation accuracy. It was reported that robotic TKA and navigational TKA allow for a higher degree of accuracy during me-

Table 6. Kaplan-Meier Survival Analysis and Cox-Adjusted Hazard Ratio for Revision Robotic, Conventional, and Navigational Total Knee Arthroplasty

Group	10-year KM survival, % (95% CI)	Cox-adjusted HR* (95% CI)	Cox-adjusted HR *p*-value
Robotic (n = 194)	97.4 (95.2–99.6)	1	-
Conventional (n = 270)	96.6 (94.4–98.8)	1.4 (0.5–4.1)	0.588
Navigational (n = 391)	98.2 (96.8–99.6)	1.4 (0.5–3.9)	0.563

KM: Kaplan-Meier, CI: confidence interval, HR: hazard ratio.
*Robotic vs. conventional or navigational, adjusted for age, sex, body mass index, side, and implant type.

chanical alignment. In our previous study, we concluded that robotic TKA led to correct mechanical alignment.[8,18] Similarly, after the introduction of computer-assisted navigational TKA, several studies have shown that the procedures with navigation can significantly reduce the risk of malalignment.[19,20] However, the long-term benefits that can be obtained by additionally increasing the accuracy of alignment and implant position are currently not supported by evidence.[21]

Our study revealed that the accuracy in mechanical alignment was not significantly higher for robotic or navigational TKA than for conventional TKA. Only the proportion of outliers in HKA axis angle showed a difference. Some previous studies comparing CAOS TKA and conventional TKA adopted a fixed 6° or 7° valgus correction in the conventional TKA group without considering the preoperative femoral deformity.[6,22] However, during the operation, we considered the preoperative femoral deformity for neutral mechanical alignment.[23] In addition, soft tissue was released for balancing the flexion and extension gap after the bony cutting procedure in three groups equally. Therefore, although the bony cut methods were different, the technique for soft-tissue balancing after bony cutting in the three groups was similar.

No significant difference was clearly identified among the three groups in the cumulative survival rate 10 years postoperatively. These results are similar to those obtained in our previous study that compared 155 patients who underwent robotic TKA and 196 patients who underwent conventional TKA. In a previous study on long-term outcomes over a 10-year period, the authors reported that both groups had excellent outcomes that were not significantly different.[24] Furthermore, in another study that compared computer-assisted surgery and conventional surgery for TKA with a 10-year follow-up, the authors also reported no statistically significant differences in survival rates between the two groups.[25] In a study that compared 100 cases of computer-assisted surgery and 100 cases of conventional surgery with a 12-year follow-up period, the authors reported that there was no difference in the long-term survival rate.[11] In addition, as described by Kim et al.[26] and Ouanezar et al.,[27] small differences in implant alignment during conventional and computer-assisted TKA may not result in a significant difference in survival rate after more than 10 years. In our study, since the same technique was applied for soft-tissue releasing and ligament balancing in the three groups, small differences in bony cutting would not lead to differences in the survival rate. Additionally, experienced orthopedic surgeons who have completed the learning curve may not benefit from performing computer-assisted TKA for soft-tissue releasing and ligament balancing. Therefore, even though there may be small implant alignment differences between the computer-assisted TKA and the conventional TKA, we observed that conventional TKA resulted in an excellent survival rate.

In a study that compared 520 knees that underwent conventional surgery and 520 knees that underwent computer-assisted navigational surgery with a mean follow-up of 10.8 years, the authors reported that the percentage of complications that required revision was very low in both groups.[26] In another study that compared 84 knees that underwent robot-assisted surgery and 79 knees that underwent conventional surgery with a mean follow-up of 10.8 years, the authors reported that there was no difference in the rate of complications between the two groups.[7] In addition, in our previous study that compared 160 knees that underwent robot-assisted surgery and 230 knees that underwent conventional surgery with a mean follow-up of 11 years, we reported that no intraoperative complication occurred in both groups, that all complications occurred during the long-term follow-up, and that there was no statistically significant difference between the two groups.[24] Unlike many studies that reported that computer-assisted TKA has a higher mechanical alignment accuracy and a lower rate of implant malposition and complication than conventional TKA,[28,29] we observed no difference in mechanical alignment among the three groups. We observed that conventional TKA did not have a higher complication rate than computer-assisted TKA.

Our study has some limitations related to the use of the collected data. First, during the long-term 10-year follow-up, almost 55% of the patients were lost for various reasons including loss of contact or death, which would have increased the survival rate. Second, unlike conventional TKA and robotic TKA, which involved the same specific implant system, navigational TKA involved a different implant system. Third, our study is a single-center study, which could lead to bias. Finally, for patients who underwent bilateral TKA, it was difficult to determine which knee functioned properly. This could have affected functional scoring. Therefore, caution is needed when interpreting the KSS and WOMAC function scores.

The strength of this study is that it is a single-center study with a large number of patients and a minimum follow-up of 10 years. We minimized bias by excluding various circumstantial factors. To our knowledge, this study is one of the largest studies comparing the long-term outcomes following robotic, navigational, and conventional TKAs.

Our study revealed satisfactory survival rates for robotic, navigational, and conventional TKAs and similar clinical outcomes during the long-term follow-up. Apart from CAOS, conventional TKA may also be a reliable option for knee osteoarthritis patients. However, larger studies with continuous serial data for functional assessment to evaluate survivorship are needed to confirm these findings.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Young Min Lee https://orcid.org/0000-0002-4349-4149
Gun Woo Kim https://orcid.org/0000-0003-0871-2371
Chan Young Lee https://orcid.org/0000-0002-1394-0902
Eun-Kyoo Song https://orcid.org/0000-0003-0765-8545
Jong-Keun Seon https://orcid.org/0000-0002-6920-5659

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