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Original Article

Comparison of Midterm Outcomes of Minimally Invasive Computer-Assisted vs Minimally Invasive Jig-Based Total Knee Arthroplasty

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ABSTRACT

Background: Minimally invasive surgery (MIS) has perceived advantages in the early postoperative stage for total knee arthroplasty (TKA). It is not clear whether the improved radiographic alignment achieved by computer-assisted navigation surgery (CAS) improves midterm clinical outcomes. The aim of this study was to compare patient outcomes of MIS TKA performed with and without CAS after a minimum follow-up of 7 years.

Methods: Between 2007 and 2009, 50 patients underwent CAS and MIS TKA, and 50 patients underwent jig-based MIS TKA in this prospective study. Ninety-six patients were evaluated after a mean follow-up of 7.7 years, and clinical and radiological evaluations were performed.

Results: Midterm results demonstrated that the Knee Society knee score, function score, and range of motion were comparable in the 2 groups. The percentage of patients with the mechanical axis within ±3° of neutral was significantly higher in the CAS group than in the jig-based group (94% vs 79%, respectively; $P = .038$). No knees had loosening after TKA. However, 1 patient in the CAS group demonstrated late infection 4 years postoperatively.

Conclusion: CAS did not improve midterm outcomes after MIS TKA compared with jig-based surgery, although CAS reduced outliers in coronal alignment.

Minimally invasive surgery (MIS) has been developed for total knee arthroplasty (TKA) to decrease early morbidity and improve patient outcomes. This technique includes a small incision and no patellar eversion [1,2]. Early results have been reported to be superior in terms of pain, muscle strength, and range of movement compared with the standard technique; however, MIS TKA could result in errors of bone cutting and implant malpositioning [1-3].

Computer-assisted navigation surgery (CAS) has been developed to aid the surgeon achieve improved alignment in knee arthroplasty [4-8]. Advocates of CAS suggest that improved placement of the implants will lead to better midterm and long-term functional and survival outcomes, although the literature lacks studies that confirm whether the improved radiographic alignment achieved by navigation improves patient function or the durability of TKA [9-16]. In addition, new technologies of combinations of CAS and MIS have gained increasing interest, and they are expected to improve short- and long-term patient outcomes. Furthermore, available comparative studies of the 2 techniques had short follow-up periods and used different assessment scales [4,17-20]. The clinical benefits are thus unclear and require definition on a larger scale.

Previously, we demonstrated that CAS and MIS TKA achieved better correction of alignment of the leg compared with jig-based MIS TKA. However, there were no functional differences between the 2 groups by 6 months [20]. We followed the original cohort of patients for a mean of 7.7 years. Therefore, in this study, the aim was to compare clinical and radiographic outcomes of MIS TKA performed with and without CAS at midterm follow-up.

Patients and Methods

In this prospective study, 100 consecutive patients were allocated to 2 groups (CAS and MIS group or jig-based MIS group)

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Table 1
Patient Demographic Data.

	CAS and MIS Group (n = 49)	Jig-Based MIS Group (n = 47)
Male:female	12:37	07:40
Age (mean ± SD), y	73 ± 8	74 ± 7
BMI (mean ± SD), kg/m^2	25.8 ± 3.6	27.7 ± 5.3
Mechanical axis deviation (mean ± SD)[a]	−2.0 ± 12.5	−3.1 ± 7.5
Diagnosis		
Osteoarthritis	45	41
Rheumatoid arthritis	4	6

CAS, computer-assisted navigation surgery; MIS, minimally invasive surgery; SD, standard deviation; BMI, body mass index.
[a] Negative values indicate varus alignment.

according to the day of the week when the surgery was done. Between June 2007 and May 2009, 50 patients each underwent primary MIS TKA using either an image-free computer-assisted navigation system (OrthoPilot; Aesculap, Tuttlingen, Germany) or a jig-based technique without navigation. No exclusion criteria were defined in terms of age, gender, or severity of the deformity. Preoperative mechanical axis deviation was measured in degrees of valgus. One patient died from unrelated causes within 5 years of the operation, and 3 patients were lost to follow-up. The remaining 96 patients were evaluated after a mean follow-up of 7.7 years (7.0-8.8 years). There were no significant differences in demographic characteristics between the groups (Table 1). Our institutional review board approved the study, and all patients provided their informed consent.

All operations were performed by 1 experienced surgeon through a midline skin incision of 8-12 cm in length using a mini-midvastus approach without patellar eversion, as described previously [20]. Posterior stabilized designs were used for all cases, and all components (Columbus; Aesculap) were fixed with cement. In the CAS and MIS group, a balanced gap technique was used. In the MIS jig-based group, extramedullary instrumentation was used for the tibial component, and intramedullary instrumentation was used for the femoral side. The proximal tibia was resected perpendicular to the shaft of the tibia in the frontal plane with a posterior slope of 0° in the sagittal plane. For the distal femur, the intramedullary alignment guide was inserted slightly medial to the midpoint of the femoral condyles. The distal femoral cutting block was set to 6° from the alignment guide.

Clinical evaluations were performed using range of motion (ROM) preoperatively and postoperatively, as well as ratings according to the system of the Knee Society preoperatively and at last follow-up. These ratings included a knee score and a function score [21]. The postoperative knee score and function score were also compared between well-aligned knees (mechanical axis within ±3°) and malaligned knees.

Radiographs were assessed for alignment of the limb, the presence of osteolysis around the 3 components, the presence of radiolucent lines at the bone–cement interface, and component loosening. Full-length standing anteroposterior and lateral radiographs were taken to determine the alignment of the components at last follow-up. The frontal mechanical axis of the leg was measured (tibiofemoral angle between a line connecting the center of the hip with the center of the knee and the line connecting the center of the knee to the center of the ankle). Radiographs were assessed by an observer who performed 2 measurements of the angles; the observer was blinded to the surgical technique used. Intraobserver reliability was within 1° on all radiographs [20].

Statistical Analysis

The Mann-Whitney *U* test and the Wilcoxon signed-rank test were used for continuous variables. Fisher's exact test and the chi-square test were used for categorical data. Correlations were analyzed using the Spearman rank correlation test. A Kaplan–Meier survivorship analysis was performed with revision for any reason as the end point. The log-rank test was used to evaluate the differences between survival curves. A P value <.05 was considered significant. Statistical analysis was performed using IBM SPSS Statistics version 22 (IBM Corp., Armonk, NY).

Results

There were no postoperative fractures at the sites of tracker pin insertions. No knees had osteolysis, loosening, or dislocations after TKA. We found no knees with radiolucent lines >1 mm. Progressive radiolucent line was not observed. However, 1 patient in the CAS group developed a late infection 4 years after surgery. This patient was treated with second-stage revision surgery.

In the CAS and MIS group, the mean flexion and extension angles at last follow-up were 120.0 ± 14.3° and −1.8 ± 5.6°, respectively. The mean ROM was 118.2 ± 17.4°. Flexion angle, flexion contracture, and ROM were improved postoperatively ($P < .001$). These angles postoperatively showed significant positive correlations with those preoperatively (flexion angle: R = 0.401, $P < .001$, flexion contracture: R = 0.506, $P < .001$, ROM: R = 0.450, $P = .002$). In the jig-based group, the mean flexion and extension angles at last follow-up were 117.1 ± 17.2° and −1.5 ± 3.4°, respectively. The mean ROM was 115.7 ± 18.5°. Flexion angle, flexion contracture, and ROM were improved postoperatively ($P < .001$). These angles postoperatively showed significant positive correlations with those preoperatively (flexion angle: R = 0.533, $P < .001$; flexion contracture: R = 0.401, $P = .006$; ROM: R = 0.514, $P < .001$). The preoperative and postoperative flexion and extension angles, as well as ROM, were not significantly different between the groups. The preoperative knee score and function score were not significantly different between the groups (Table 2). The scores at the time of the last follow-up were also not significantly different between the groups (Table 2). Both knee scores and function scores improved significantly postoperatively ($P < .001$).

The percentage of patients with the mechanical axis within ±3° of neutral was significantly higher in the CAS group than in the jig-based group (46 patients [94%] vs 37 patients [79%], respectively; $P = .038$). The mean knee scores were 92.8 ± 10.1 points and 89.8 ± 10.8 points in the knees with the mechanical axis within ±3° of neutral and greater than 3°, respectively. The mean function scores were 64.9 ± 23.6 points and 60.4 ± 29.3 points in the knees with the mechanical axis within ±3° of neutral and greater than 3°, respectively. Both knee scores ($P = .118$) and function scores ($P = .931$) showed no differences between the group with the mechanical axis within ±3° and that with malaligned knees.

Table 2
Mean (±SD) Clinical Scores According to the Knee Society [21].

	CAS and MIS Group (n = 49)	Jig-Based MIS Group (n = 47)	*P* Value
Knee score			
Preoperative	32 (18)	31 (17)	.855
Last follow-up	94 (8)	91 (12)	.160
Function score			
Preoperative	43 (24)	38 (21)	.256
Last follow-up	66 (25)	62 (23)	.464

CAS, computer-assisted navigation surgery; MIS, minimally invasive surgery.