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Minimally Invasive Computer-Assisted Total Knee Arthroplasty Compared With Conventional Total Knee Arthroplasty: A Prospective 9-Year Follow-Up

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ABSTRACT

Background: Studies on minimally invasive computer-assisted total knee arthroplasty (MICA-TKA) have shown promising results, but are limited by short follow-up. The purpose of this study was to compare the midterm radiographic features and functional outcomes between patients who underwent MICA-TKA and conventional TKA.
Methods: A total of 108 patients who were randomized to undergo MICA-TKA or conventional TKA during 2004 and 2005 were contacted for a prospective follow-up review. Patients who were lost to contact, have passed away, or declined to participate in the study were excluded. Objective functional measurements and radiographs were obtained for assessment.
Results: By the time of this study, 2 patients from the conventional group had undergone revision TKA, one due to infection and one due to aseptic loosening. A total of 67 patients (62.04%) were followed up for an average period of 9.07 years (8.51-9.61 years). At follow-up, functional scores were comparable between the 2 groups. No significant intergroup differences were found in mechanical knee alignment and component placement angle in the coronal views. No statistical or clinical significance were noticed in radiographic signs of component loosening.
Conclusions: MICA-TKA provided similar clinical, functional, and radiographic outcomes compared with conventional TKA after an average of 9-year follow-up. This technique can be used to exploit its short-term advantages without compromising midterm outcomes.

Total knee arthroplasty (TKA) has emerged as one of the most successful treatment in orthopedic surgery, providing good long-term results with regard to pain reduction, functional improvement, and overall patient satisfaction. Minimally invasive approach has been successfully applied in TKA to provide patients with reduced postoperative pain, less blood loss, and accelerated rehabilitation [1,2]. This approach uses a skin incision less than 14 cm and a mini medial parapatellar approach with no patellar eversion and no tibiofemoral joint dislocation, which help in minimizing soft tissue dissection [3,4]. However, some studies warn of problems such as poor wound healing and incorrect component orientation associated with the minimally invasive approach [2,5]. The risk of prosthetic malalignment due to decreased visualization of the operative field has been reduced by the introduction of computer-assisted navigation system, which was designed to increase precision of the implantation [6–9]. Combining these 2 techniques, minimally invasive computer-assisted TKA (MICA-TKA) is expected to improve early postoperative recovery with less invasive exposures while retaining the accuracy of implant and limb alignment through computer navigation.

In an earlier study by the authors, MICA technique has shown to improve postoperative radiographic alignment and early functional recovery, without increasing short-term complications [10]. Other studies have also established the promising results with MICA-TKA, but most are limited by their short follow-up [11–17]. One study with an average 6.1-year follow-up found no significant differences

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in clinical and radiographic outcomes of minimally invasive TKA performed with and without computer-assisted navigation [18]. Another population-matched study confirmed that 5-year functional outcome is not compromised when minimally invasive surgery was combined with computer-assisted TKA [19]. Clinical, functional, and radiographic benefits of MICA-TKA are still unclear and largely remain to be defined, especially in the mid to long term.

The purpose of the current prospective follow-up study was to compare the midterm radiographic features and functional outcomes between patients who underwent MICA-TKA and those who underwent conventional TKA. The authors hypothesize that MICA-TKA can provide similar radiographic accuracy and achieve comparable clinical and functional improvement compared with conventional TKA at the follow-up.

Material and Methods

In 2004-2005, the authors conducted a prospective randomized study involving 108 patients who were scheduled to undergo either conventional TKA or MICA-TKA [10]. For the present study, all the 108 patients were contacted by phone or mail to return to hospital for a prospective follow-up review. Patients who were lost to contact, have passed away, or declined to participate in the study were excluded. Patients who had subsequent revision TKA were considered for survivorship analysis, but excluded from other analyses.

In the previous study, 56 patients were randomized to undergo conventional TKA and 52 patients to undergo MICA-TKA, based on computer-generated random numbers. The conventional TKA was performed as described in the technique manual provided by the manufacturer (DePuy, Warsaw, IN). A mini medial parapatellar approach combined with an imageless computer navigation system (Ci total knee replacement, version 1.0; DePuy or Brainlab, Feldkirchen, Germany) was used to perform the MICA-TKA. The midline skin incision was less than 10 cm long. An abbreviated quadriceps tendon-splitting approach was used, without patellar eversion. All components (femoral, tibial, and patellar) were cemented, and a tourniquet was used throughout the procedure in all cases. Perioperative pain management, prophylaxis against deep vein thrombosis, and physiotherapy were standardized.

Staff from Orthopaedic Diagnostic Centre, which includes technicians, clinical outcome executives, and physiotherapists, who were blinded to the type of surgery performed, completed the objective functional measurements and scoring questionnaires both preoperatively and at the follow-up. Oxford Knee Score, Knee Society Score (KSS), Short Form-36 (SF-36) Score, and range of motion were assessed. Patients' overall satisfaction of the treatment was assessed on a 6-point Likert scale.

Long-leg radiographs in the coronal plane and lateral knee radiographs (with the knee flexed) were obtained for radiographic alignment analyses. Two independent, blinded assessors performed the radiographic measurement of 5 component angles: (1) hip–knee–ankle angel (the angle subtended by the femoral and tibial mechanical axes; neutral = 180°); (2) coronal femoral component angle (the angle between the mechanical axis of the femur and the transcondylar line of the femoral component; neutral = 90°); (3) coronal tibial component angle (the angle between the mechanical axis of the tibia and the tibial base plate; neutral = 90°); (4) sagittal femoral component angle (the angle between the anatomic axis of the femur and the transcondylar line of the femoral component; neutral = 90°); and (5) sagittal tibial component angle (the angle between the anatomic axis of the tibia and the tibial base plate; neutral = 90°, with a 4° posterior slope being recommended by the manufacturer). Measurements were taken to an accuracy of 0.1°, and average value was recorded. Remeasurement was performed if the difference on a particular component angle between the 2 assessors was greater than 2°.

Radiographic signs of component loosening were evaluated according to the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System [20]. Briefly, the maximal width of the radiolucent lines between the components and bone cuts was measured for each of the 3 (femoral, tibial, and patellar) components. For the femoral component, 7 zones on the sagittal view were examined. For the tibial component, 7 zones on the coronal view and 3 zones on the sagittal view were examined. Finally, 5 zones on the Merchant view were examined for the patellar component. If the sum of the widths of radiolucencies in any component was greater than 10 mm, that component was considered loosening.

The hospital ethics committee approved the study protocol before the conduct of the study and audited the process (SingHealth CIRB: 2012/865/D). The study was carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki; and informed consent was obtained from all patients.

Statistical Analysis

Patients' demographics and preoperative assessment results were compared for those who were included in the present study, between the MICA-TKA and conventional TKA groups. The intragroup baseline features were also compared between those who were included and excluded in the present study based on the original randomization groups, to rule out any transfer bias.

Statistical analyses were carried out using SPSS 21.0 (IBM, Armonk, NY). Testing for normality was done with the Shapiro–Wilk test. The Mann–Whitney *U* test was used for continuous variables with non-normal distribution (SF-36, KSS, and Oxford Knee Score; interquartile range was reported), whereas the Student's unpaired *t* test was used for continuous variables with normal distribution (age, body mass index, range of motion, and all component angels; standard deviation was reported). For categorical variables, the Pearson's chi-square test was used. Statistical significance was defined as a *P* value of $\leq$.05.

Results

A total of 67 patients (62.04%) were included in this study, 30 from the MICA-TKA group and 37 from the conventional TKA group. The average follow-up period was 9.07 years, ranging from 8.51 to 9.61 years. By the time of this study, 2 patients from the conventional TKA group had undergone revision TKA, one due to infection and one due to aseptic loosening. Other than those who were loss to contact, no patient in the excluded group had undergone any revision TKA. The 9-year survival rate was 92.9%-96.4% (worst case-best case scenario) for conventional TKA and 90.4%-100% for MICA-TKA. The detailed patients' follow-up flow chart was illustrated in Figure 1.

Both studied groups showed similar preoperative demographics and assessment results (Table 1). Other than the excluded patients in the conventional group were on average older than those included (71.8 vs 65.3, *P* = .004), there were also no significant differences in the baselines between those who were included and excluded from this study in either group.

As shown in Table 2, functional scores were comparable between the 2 groups; and patients from both groups reported similarly high satisfaction toward the overall results of treatment. There is no significant difference in mechanical knee alignments and component placement angels in the coronal views. In the sagittal views, the femoral components demonstrated a more extensional configuration in the conventional group, in contrary to a more flexional configuration in the MICA group (1.6° extension vs 1.6° flexion,