

Robot-assisted implantation improves the precision of component position in minimally invasive total knee arthroplasty – a controlled cadaveric study using three-dimensional CT assessment of the alignment

MOON YW, PARK YS, HA CW, KIM SM

Department of Orthopaedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

heavystone75@gmail.com

Background: Both minimally invasive and robot-assisted procedures have potential advantages when used for total knee arthroplasty (TKA). We hypothesized that minimally invasive TKA using modified robot-assisted techniques would provide a better lower limb alignment and component orientation than conventional surgery. To test this hypothesis, we quantitatively compared radiologic outcomes of robot-assisted minimally invasive TKA with those of the conventional TKA using three-dimensional computed tomography (CT) in a human cadaveric model.

Methods: Total knee replacements were performed on 10 pairs of fresh cadaveric femora. Ten knees were replaced using minimally invasive robot-assisted technique, and the other 10 knees using conventional technique. The ROBODOC system (CUREXO, South Korea) was applied in robot-assisted TKA. NexGen cruciate-retaining total knee prostheses (Zimmer, Warsaw, IN, USA) with fixed bearing were applied to all the knees. For minimally invasive procedure, the robot-assisted techniques need modifications in terms of fixation method, digitizing tool, and cutting procedures. To optimize milling process under limited exposure, new cutting device and tissue sparing tunneling method were developed. The diameter of cutter was decreased from 7.8mm to 4mm and only one type of cutter was used in the both femur and the tibia. Tissue sparing tunneling method modified cutting pathway and cutting steps for minimally invasive surgery. After implantation of the prostheses, limb and prosthesis alignments were investigated by measuring mechanical-axis deviation, sagittal inclination of the femur and tibia, coronal inclination of the femur and tibia, and femoral rotational alignment with three-dimensional computed tomography scans. Two observers measured the preoperative and postoperative CT scans twice each at one-month intervals. Outcome was defined as “acceptable” when within 3°, and as “outliers” when more than 3° from optimum.

Results: Radiographic results of robotic MIS-TKA and conventional surgery was summarized in Table 1. The accuracy of postoperative alignment of implanted prostheses was better in robot-assisted minimally invasive group than conventional surgery group as judged by the rotational alignment of femoral component (0.7 ± 0.3 versus 3.6 ± 2.2) and the tibial component sagittal angle (7.8 ± 1.1 versus 5.5 ± 3.6). In terms of outliers, there was only 1 sagittal inclination outliers for the tibial side in the robotic surgery group, but 2 outliers for mechanical axis, 2 for tibial side sagittal inclination, and 2 for femoral rotational alignment in the conventional surgery group. The intraclass correlation coefficients of inter- and intra-observer variabilities were 0.83 and 0.88, when calculated with all measurements.

Conclusions: Higher accuracies of implanted prostheses and lower number of outliers in the postoperative radiographic alignments could be reached with the robot-assisted surgery. Minimally invasive TKA in combination with improved robot-assisted technique would be an alternative option to compensate for shortcomings of the conventional minimally invasive surgery.

	Robodoc MIS-TKA	Conventional TKA	<i>p</i>
Medial mechanical femorotibial angle	0.2°±1.1° (-1.4°~1.9°)	-0.5°±2.8° (-3.2°~3.8°)	0.611
Femoral component coronal angle	90.3°±1.0° (88.8°~91.7°)	90.5°±1.2° (88.4°~92.3°)	0.891
Tibial component coronal angle	90.0°±1.1° (89.0°~92.2°)	89.8°±1.2° (88.2°~91.5°)	0.874
Femoral component sagittal angle	3.1°±1.7° (1.8°~4.7°)	4.6°±2.2° (2.2°~6.1°)	0.233
Tibial component sagittal angle	7.8°±2.1° (4.0°~9.2°)	5.5°±3.6° (2.7°~9.9°)	0.010
Rotational alignment of femoral component	0.7°±0.3° (0.3°~1.2°)	3.6°±2.2° (0.9°~5.9°)	0.027

Table 1. Comparison of radiologic results between robotic MIS-TKA and conventional TKA