Accuracy of Additional Bone Resection with Robotic Technology for Tibial Bone Defect of Severe Varus Knee in Total Knee Arthroplasty with Metal Block Augmentation

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INTRODUCTION: Total knee arthroplasty (TKA) for a severe varus knee with a medial tibial bone defect remains challenging for orthopedic surgeons, because of the technical difficulty associated with additional bone resection to remove the bone defect area, application of metal augmentation, and adjustment of soft tissue balancing. Robotic technology has been proven to achieve accurate bone resection and optimal soft tissue balancing in TKA (1). We hypothesized that additional bone resection for a bone defect can be easily and accurately performed by robotic technology. This study aimed to present a case series of the application of robotic-assisted TKA (RTKA) with metal augmentation for severe varus knee.

METHODS: This single-center, single-operator retrospective case series study included 15 patients (4 men and 11 women) with 22 affected knees and postoperative follow-up ≥12 months. Primary TKA with metal block augmentation and tibial stem extension was performed using a computed tomography-based, intraoperative surgeon-controlled semiactive saw-cutting robotic system with visual, tactile, and audio feedback (Mako, Stryker, Mahwah, NJ, USA). For RTKA preparation, the distal femoral and proximal tibial registration pins were inserted, and the fixed arrays were mounted onto these pins for intraoperative dynamic referencing. To avoid obstructing the insertion of the prostheses, the tibial registration pins were set further than the tibial implant and stem lengths from the tibial joint line, which were at least >15 cm below the line. After the bone registration for the initial setup of the Mako system, femoral and tibial osteophytes and cruciate ligament(s) were removed, and the joint balancing in extension and 90° flexion was assessed under manual valgus and varus stress tests for the medial and lateral tibiofemoral joint gaps, respectively. To maintain the physiological medial stability of the knee, the primary medial static stabilizer ligaments were preserved as much as possible (2). After adjusting the joint gaps by varying the thickness of bone resections and implant positions, the initial femoral and tibial bone resections were performed with mechanical alignment using the Mako system, and the spacer block was inserted to confirm alignment and soft tissue balancing. However, a bone defect that was still more than one-third of the surface area of the medial compartment and deeper than 5 mm at this time point requires additional bone resection and metal block augmentation. Tibial implant orientation, which involved determining the appropriate size, center, anteroposterior rotational alignment, and medial and lateral edges, could also be confirmed in the Mako system. Subsequently, additional bone resection was performed, and the metal half block and tibial stem extension were applied. Patients were allowed to start postoperative rehabilitation with full-weight bearing from the first day after TKA, and the implant positions, soft tissue balancing, and clinical outcomes were evaluated. For the statistical analysis, paired t-test and Wilcoxon signed-rank test were conducted to compare the variation in clinical and radiographic outcomes with a significance value of 0.05. Written consent was obtained from all patients. This study was approved by the institutional review board.

RESULTS SECTION: Preoperative knee range of motion in extension and in flexion, visual analog scale score, and scores on all items of the knee injury and osteoarthritis outcome score were significantly improved after RTKA ($p < 0.05$). The radiographic lateral femorotibial angle and hip–knee–ankle angle were also significantly improved ($p < 0.05$). In addition, the implant positions in the coronal and sagittal planes were radiographically accurate. Moreover, preoperative tibiofemoral joint gaps narrowed medially but widened laterally in both extension and flexion. However, the medial knee became stable, and the lateral looseness diminished postoperatively. No critical complications, such as periprosthetic joint infections, periprosthetic fractures, pin site problems, revision TKA, and RTKA-associated readmissions were documented during the follow-up period.

DISCUSSION: In addition to primary bone resections, the use of robotic technology facilitated accurate residual bone defect evaluation, soft tissue balancing, and additional bone resection to remove the bone defect area. Additional bone resection with metal augmentation implants is commonly performed in severe varus knee deformities with a medial tibial bone defect measuring approximately 5–10 mm after proximal tibial bone resection. The tibial bone resection guide is generally used; however, re-installing the resection guide accurately parallel to the tibial surface after the primary proximal tibial resection is challenging. The robotic technology facilitated additional transverse bone resection with precision, which could be verified on the bony surface and resected bone fragment (Fig. a–c). Before bone resection, the depth of additional bone resection was also decided based on the images displayed on the monitor, which also confirmed the accuracy of the present results. Moreover, the insertion point of the stem, along with the mediolateral position and anteroposterior rotational alignment of the tibial component, was confirmed using a navigated pointer shown on the monitor. Consequently, the implant positions were confirmed to be accurate. However, this study was limited by the small number of cases, short-term follow-up, and the lack of a control group. Thus, analysis of more cases is necessary. Despite these limitations, this study demonstrates the advantages of robotic technology for TKA with metal block augmentation in severe varus knee with a medial tibial bone defect.

SIGNIFICANCE/CLINICAL RELEVANCE: TKA for a severe varus knee with a medial tibial bone defect remains challenging. However, the use of robotic technology facilitates additional bone resection to remove the bone defect area, accurate lower extremity alignment, and adjustment of optimal soft tissue balancing.

REFERENCES:
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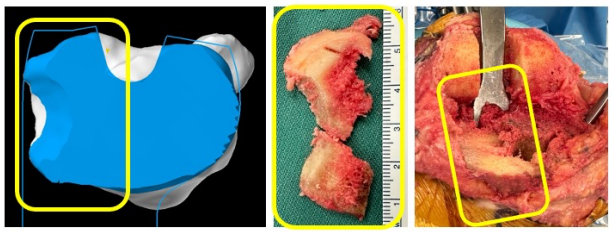
FIGURES: (a) Bone surface after additional bone resection as shown on the computer monitor. The white area was additionally resected. (b) Additionally resected medial tibial bone. (c) Tibial bone surface after the additional bone resection, which was similar to (a).



(a) (b) (c)