INTRODUCTION. Technology for precise milling of the femoral cavity in THA is provided by the Robodoc® Surgical Assistant from Integrated Surgical Systems, Inc. using a programmed robot. While this technology holds potential for improvement of hip replacement procedures, the extent to which the milling truly coincides with the 3D planning, and the accuracy with which the resulting cavity allows the intended placement of the prosthesis to be realized, remain independently unreported. Ultimately, clinical results will determine the efficacy of any surgical procedure, but it is has been shown particularly in the case of coated cementless hip stems that the better the initial approximation of the host bone to the prosthesis surface, the higher its chances of establishing bony ingrowth and anatomically integrated stability. The objective of this study was to quantify the efficacy of the Robodoc® system in achieving correct placement of an anatomical hip stem. The system was compared to conventional cavity preparation in all three translational and rotational parameters.

METHODS. Ten matched-pairs of fresh-frozen cadaveric femurs were divided intrapair-wise between Robodoc® and conventional test groups (n=10 for both groups). Planning of all femurs using the Antega® hip stem (Aesculap AG, Tuttlingen, Germany) was performed on the Orthodoc® station, based on 3D reconstruction of a CT scan. To evaluate first the changes to the natural anatomy due to the planning of the implant position, various landmarks, both anatomical and prosthesis-based, were referenced to consistently orient the scans and determine neck-shaft angle, anteverision, and sagittal inclination, as well as attendant translations of the rotational head center in the three primary directions (Fig.). The measurement of neck-shaft angle and anteverision, in particular, relied on new methods developed to enhance interobserver repeatability; all were completed by three observers. In the case of the conventionally-prepared specimens, the plan by definition could not be utilized for implantation but served rather as an idealization of hip stem placement. Following milling of the Robodoc specimens and broaching of the conventional specimens, the appropriate-size prosthesis was inserted under normal surgical conditions, then the specimen rescanned. Post-op measurement was made of the resulting rotations and translations using the same methods as used pre-operatively. Implanted data were compared to planned data to determine the efficacy of realizing the plan in the robot group, and the approximation to the otherwise intended position in the conventional group. Statistical analysis used a MANOVA test (alpha, 0.05).

RESULTS. Change in leg length represented the largest difference between the two techniques, with the robot group deviating -0.2 mm (median value) from plan (SD, 2.9), and the conventional group, 6.3 mm (SD, 3.7; p<.05). Smaller differences were noted in anteversion, with the robot group deviating 1.0° from plan (SD, 1.6°), the conventional group 1.8° (SD, 7.6°); in neck-shaft angle, with the robot group deviating 0.1° from plan (SD, 0.3°), the conventional group -0.1° (SD, 1.5°); in mediolateral offset, with the robot group deviating 0.4 mm (SD, 2.1 mm), the conventional group 1.5 mm (SD, 3.7 mm); and in AP-translation, with both groups deviating by 0.0 mm in median but with SDs of 2.5 and 3.8 mm, respectively. In inclination, SD for both groups was prohibitively large due to difficulty in standardizing its measurement, thus median is not reportable. Consistently, SD was higher for the conventional group than for the robot group. Planned changes to the anatomy were only slight and similar between the two groups.

CONCLUSIONS. The extensive use of the Robodoc® in Germany provides a useful clinical database for consideration of its use in the world market. However, the technical accuracy of realizing the planned placement of a prosthesis remains unproven, and the follow-up period is not yet far enough out to assure its long-term efficacy, although there are no reports to suggest that its performance is notably suspect. Indeed, fracture complications have been reduced and weight-bearing has proceeded ahead of conventionally-implanted cases on average. This study showed the tendency of conventional THA with this anatomical prosthesis to nonoptimally control the depth of seating the hip shaft, and the potential for more accurately realizing the intended depth position with a robot. In other placement coordinates, the planned position is less reliably achieved with conventional instruments, although the averaged result of the two methods is similar and not statistically different.