INTRODUCTION
The surge in the adaptation of robotic technology for operative assistance in a comprehensive range of surgical fields in the last three years speaks for a new era in the precision with which tumors, stenoses, and diseased joints are treated. In the orthopaedic field this technology has its most established application in hip replacement surgery, where the goals are to improve the reliability of placement of the prosthesis stem and to optimize the amount of bony contact in the trabecular bone region proximally.

The Robodoc® system from Integrated Surgical Systems (Davis, California, USA) provides an Orthodoc® computer station for planning the implantation procedure in three dimensions, based on CT scan data. The system is currently under review for FDA approval in the U.S., over a thousand cases, however, have already been performed in Germany and elsewhere in Europe. Others (1) recently compared femoral neck and antetorsion angles pre- and post-operatively in cadaveric femur groups using in one case conventional manual techniques and in the other this robotic system. They found that the system was especially effective in controlling antetorsion angle. The goal of the current study was to more meaningfully describe the changes in related, anatomically relevant parameters, based on translational coordinates, and to differentiate the analysis between changes due to planning and those due to execution of the planning. An advantage of the current study is that it comprises matched-pair femurs.

METHODS
Ten pairs of donor femurs were obtained fresh then maintained frozen at minus 20°C until scanning and testing. A two-pin registration system was employed, with one 10-mm proximal pin set into the anteromedial aspect of the femur slightly above the trochanter minor, and one 30-mm distal pin set into the medial condyle. The femurs were scanned in a Siemens Somatom +4 model using a spiral CT method. Radiographs were obtained in A-P and lateral views using a perpendicular block and podiatric orthosis foam to assure trueness and orthogonality of the two views.

Preoperative antetorsion was measured in the lateral radiograph, and mediolateral offset and leg length in the A-P radiograph by each of the authors, then averaged. After pair-wise random assignment to the manual and robot groups, the femurs were blindly planned for operation with an Antega® anatomical hip stem prosthesis from Aesculap AG & Co. KG (Tuttlingen, Germany) using respectively the radiographs or the Orthodoc® planning station. Measurements based on intended prosthesis position in both mediums were repeated before implantation to isolate the effect of planning. Following cavity preparation and implantation, with all manual aspects of the various procedures performed by the senior surgeon, the femurs were again radiographed and CT-scanned, then measured postoperatively. Statistical analysis consisted of a Kruskal-Wallis analysis of variance using a level of significance of 0.05.

RESULTS
Leg length change due to implantation in the manual group (table) was 7.5 mm (SD 4.9); the planning strategy in this group used matching of the prosthesis and natural femoral heads, thus in this instance there was no effect of planning. In the robot group, leg length change due to planning was 1.1 mm (SD 1.0), and due to implantation, 0.2 mm (SD 0.2). This difference was statistically significant compared to the manual group. Mediolateral offset change in the manual group due to planning was -3.4 mm (SD 3.4), and in the robot group -7.5 mm (SD 3.6). Both implantation procedures followed closely to plan regarding this parameter, with the manual group producing a deviation of 0.3 mm (SD 0.2), and the robot group, 0.2 mm (SD 0.1; not significant). Antetorsion angle change in the manual group due to planning was 2.7° (SD 1.8), and in the robot group 1.5° (SD 1.6). The planned change was better realized in the robot group with an implantation deviation of 1.1° (SD 0.9) than in the manual group with 4.7° (SD 3.0; significant).

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<th>Planned vs. Natural</th>
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<td>Manual</td>
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Leg Length 0.0 (0.0) 7.5 (4.9) 1.1 (1.0) 0.2 (0.2)

M-L Offset -3-4 (3.4) 0.3 (0.2) -7.5 (3.7) 0.2 (0.1)

A-T Angle 2.7 (1.8) 4.7 (3.0) 1.5 (1.6) 1.1 (0.9)

DISCUSSION
In leg length and antetorsion angle, the robotically-prepared femoral cavities deviated significantly less from plan than their contralateral manual counterparts. In mediolateral offset, there was no difference. An earlier in vitro study (1) showed antetorsion angle to change substantially (10.8°) with manual preparation but only negligibly with robotic preparation. Since that study did not separate the effects of planning and implantation, it is difficult to assess the source of the difference. The difference in leg length found in this study is the first translational discrepancy to be reported in this type of evaluation. Clinically, the Robodoc® system has demonstrated good results with the earlier cases now exceeding five years follow-up (2).

REFERENCES