INTRODUCTION

Acetabular cup positioning and alignment are critical factors affecting the impingement-free range of motion, leg-length, and dislocation potential with total hip arthroplasty. Methods to improve cup placement accuracy have included intraoperative imaging, image-based and non-image-based navigation systems, and now haptic or hands-on robotic surgical assistants. The purpose of this study was to quantify acetabular cup placement errors in total hip arthroplasty using standard instrumented techniques and using haptic robotic guidance.

METHODS

Twelve total hip arthroplasties were performed bilaterally on six cadavers. The surgeries were planned based upon preoperative CT scans. One side of each specimen was operated with standard instrumented techniques while the other was carried out using haptic robotic guidance for reaming and cup impaction. Postoperative CT scans were acquired and segmented to identify the implants and bone. Three-dimensional cup placement errors were assessed by comparison of the preoperative plan and the postoperative scans (Figure 1).

RESULTS

Cup inclination errors (root mean squared) averaged 11.6 deg and 2.3 deg for manual and robotic surgeries, respectively (p = 0.01). Cup anteversion errors averaged 8.9 deg and 2.6 deg for manual and robotic surgeries (p = 0.01). Cup location errors averaged 4.1 mm and 2.8 mm for manual and robotic surgeries (p = 0.13). Individual accuracy results are reported in Table 1.

DISCUSSION

Accurate acetabular cup placement is associated with increased impingement-free range of motion, improved wear performance, and lower dislocation rates. Our in vitro data suggest that robotic assistance in cup reaming and impaction can result in a significant improvement in cup placement accuracy. Additional patient trials will be required to determine if similar improvements are realized in clinical practice.

SIGNIFICANCE

Current manual instrumentation techniques are not suitable for accurate cup reaming and impaction in total hip arthroplasty, resulting in increased dislocation rates, impingement and wear. Using a robotic-assisted surgical technique, acetabular cup placement was achieved within 1.9 mm and 2.6 deg of a preoperatively planned position with the goal of improving implant performance and longevity.