

Comparison of manual rasping and robotic milling for a short metaphyseal fitting stem implantation in total hip arthroplasty: a cadaveric biomechanical study

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Background: The ROBODOC system has the theoretical advantages of providing a proper fit and better mechanical stability of the stem in cementless total hip arthroplasty. However, the mechanical stability of short metaphyseal-fitting stems implanted by robotic milling has not been studied. We hypothesized that robotic milling would provide better fit and mechanical stability for short metaphyseal-fitting stems than those obtained by manual rasping technique. To test this hypothesis, we quantitatively compared the primary stability of a short metaphyseal-fitting stem implanted by robotic milling or manual rasping in a human cadaveric femoral model.

Methods: Nine matched pairs of human cadaveric femora were used. Each pair was randomly assigned to robotic milling group or manual rasping group. Metha short-stem prosthesis (B. Braun Aesculap; Tuttlingen, Germany) was used in all cadaveric femora. Robotic-assisted THA involves a computed tomography (CT) scan, preoperative planning using the workstation, robot diagnostics and preparation, exposure and registration, and robotic milling of the femur. In the manual rasping group, the surgeon performed progressively larger manual handheld rasping until enough axial and rotational stability of the appropriately sized rasp was felt in the femoral canal. After implantation, each specimen was positioned at an adduction angle of 16° in the frontal plane with 9° posterior tilt in the sagittal plane to create physiological loading, and was loaded dynamically (58.8-588N) for 1200 cycles at a frequency of 1 Hz to evaluate primary stabilities. The data analysis methods used are as follows; Initially, LVDT sensors were zeroed. Second, displacement values were recorded using the two LVDT sensors. And then, these values are then used to calculate displacement values and rotational angles.

Results: During stability testing, the robotic milling group showed less motion and reduced variability in magnitude in terms of the migration in the proximal-distal direction, migration in mediolateral direction, and rotational angle than the manual rasping group, although the trends did not reach statistical significance ($v=0.24\pm0.18\text{mm}$ versus $0.32\pm0.59\text{mm}$, $p=0.34$, $h=0.54\pm0.25\text{mm}$ versus $0.66\pm1.24\text{mm}$, $p=0.44$, and $\theta=0.48\pm0.22^\circ$ versus $0.59\pm1.09^\circ$, $p=0.44$, respectively). In the robotic milling group, no intraoperative femoral fractures occurred, whereas in the manual rasping group two femoral neck fractures occurred during stem implantation. In addition, we also found a femoral cortical perforation at the distal stem tip by postoperative CT image in one specimen in the manual rasping group. All implants in both groups showed a biphasic pattern of migration with increasing load, which consisted of a relatively steep initial increase, followed by a relatively low displacement phase, which we refer to as the 'stable' phase. 'Stabilization' was observed for both groups within 200 to 400 cycles.

Conclusions: Our results suggest that robotic milling seems to have advantages in terms of increasing primary stem stability and reducing the risk of femoral fractures during a short metaphyseal-fitting stem implantation. In addition, this study cautions that manual rasping for short stem implantation needs to be performed carefully to avoid intraoperative femoral fracture. A further long-term follow-up *in vivo* study is required to clarify whether the better radiographic results and reduced fracture rates achieved by robotic milling lead to significant long-term improvements.